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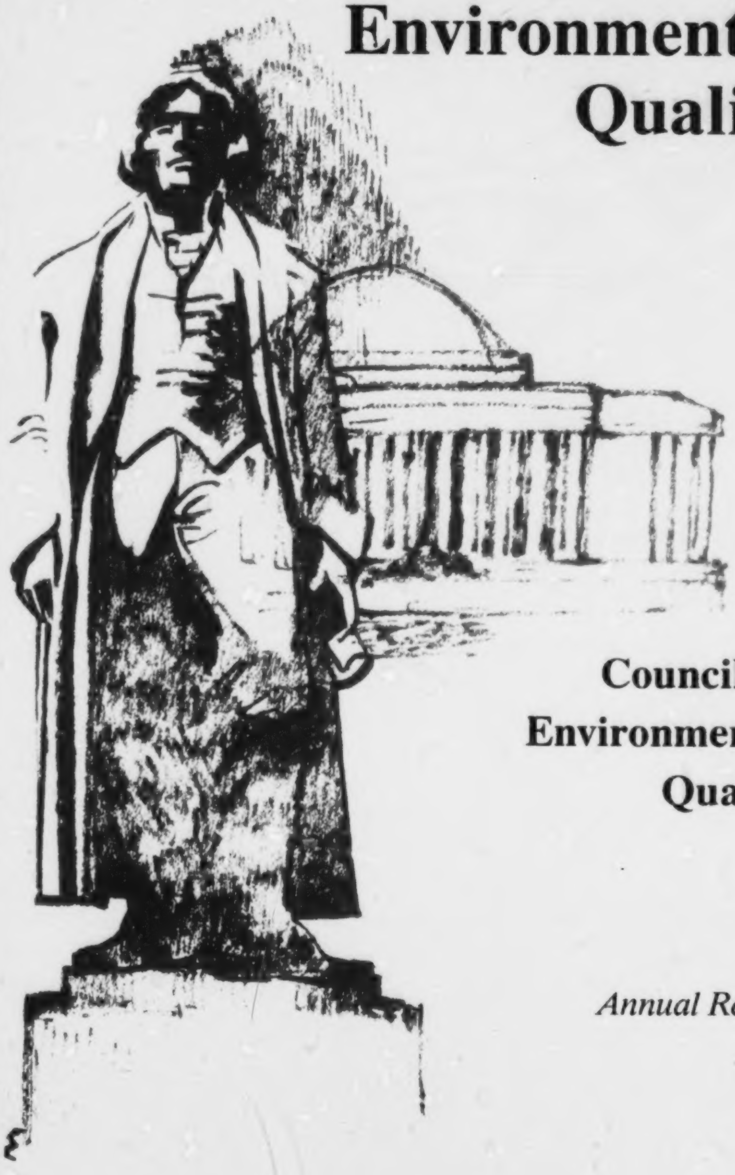
Environmental Quality



Council on
Environmental
Quality

Annual Report

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EXECUTIVE OFFICE OF THE PRESIDENT OF THE UNITED STATES
COUNCIL ON ENVIRONMENTAL QUALITY

Environmental Quality

*The Eighteenth and
Nineteenth Annual Report
of the Council on
Environmental Quality
together with The President's
Message to Congress*

The President's Message

TO THE CONGRESS OF THE UNITED STATES:

I am pleased to transmit to the Congress the annual report of the Council on Environmental Quality, *Environmental Quality 1987-1988*. This report focuses on the Nation's air, land, and water resources that are particularly affected by the urbanization of our population and by other intensive uses. It presents CEQ's analysis of the historical trends, current status, and outlook for urban air quality, developed water resources, and the growing burden of municipal solid waste on the urban landscape. It also offers an assessment of the Federal lands reserved for our national defense installations, which present special environmental challenges.

Americans built great cities that have facilitated commerce and economic growth and prosperity, and provided homes to millions of new citizens from all over the world. Today nearly three-fourths of our people reside in communities classified as "urban," which make up only about 2 percent of this country's total land acreage. As our Nation has generally prospered by intensively developing these urban areas, expectations for human health and quality of the natural environment have also increased.

Hence, for nearly 2 decades, governments at all levels have increased their efforts to address pollution and environmental degradation. Parallel efforts in the private sector have accompanied government programs to protect the human environment. As a result, we can point proudly to improvements on a number of fronts. Some of these are reviewed in this CEQ report. For example, the Federal motor vehicle control program, which sets emissions standards for all new production vehicles, has brought about a clearly demonstrated improvement in the quality of the air in cities throughout the Nation.

But we can do better. That is why we are committed to cleaner air in the Nation's cities, and why we believe that a fresh approach to the Clean Air Act can help meet the Nation's environmental needs without compromising our record of unprecedented economic growth. It is now clear that different cities have varying climatic conditions, industrial mixes, and automobile use patterns. Cleaner air in our cities will thus require credible commitment, timetables, and strategies for the different regions of the country. Innovative solutions tailored to meet local circumstances will be required. Draconian limits on economic growth and on the use of the automobile should not be necessary in order to give Americans clean air at levels they are willing to pay for, but it will require significant Federal, State, and local leadership and innovative approaches from government and industry.

We must do better. This country must make every effort to stem the rising tide of garbage and industrial waste through a more aggressive use of waste minimization and recycling practices. America as a nation is filling landfills faster than it can establish new ones. The waste problem is not going away, and it can no longer be neglected. Waste minimization must start at home and in the local communities, by reducing household garbage and separating wastes for recycling. In many cases it is in the economic self-interest of industry to recycle its wastes, to minimize waste generation at the source, or to adopt less polluting processes. Innovative techniques that have proven effective in reducing wastes both in industry and in local communities should be widely shared.

We will do better. The development of America's abundant water resources has stimulated economic advancement in nearly all regions of the country and has facilitated growth in interstate commerce generally. Since 1972, a national expenditure of $350 billion for water pollution abatement and control has restored water quality in many places so that today some three-fourths of our rivers, lakes, and estuaries can fully support fishing and swimming. But the pollution that washed ashore on popular beaches last summer has again focused attention on the condition of the Nation's coastal waters. Abuses of the oceans and the Great Lakes must end and will end, and we will work closely with the States to enforce and strengthen the effectiveness of the Ocean Dumping Act and the Clean Water Act. We must also better protect America's wetlands, by working towards a goal of no net loss through a coordinated wetlands policy. We are also committed to protecting the Nation's surface and ground water resources from contamination by fertilizers and pesticides without jeopardizing the economic vitality of U.S. agriculture, and we will work with farmers to adopt environmentally sound production practices, safer chemicals, and biological pest controls.

Doing a better job of cleaning the air will make our cities more healthful. Doing a better job of solid waste management will make our landscapes safer and more attractive. Doing a better job of protecting our water resources will add importantly to the overall opportunities for outdoor recreation within and near our urban communities, closer to where most Americans spend most of their time. Recent studies of outdoor recreation have pointed out the enormous popularity of water-based recreation activities and have stressed the positive relationship between improvements in water quality and the effective use of urban lands available for outdoor recreation.

A better life for all Americans is our great common desire, and I believe that economic growth and a clean environment are both part of what all Americans understand a better life to mean.

The protection of the environment and the conservation and wise management of our natural resources must have a high priority on our national agenda. Given sound research, hard work, sufficient public and private funds, and — most important — the necessary political will, we can achieve and maintain an environment that protects the public health and enhances the quality of life for us all.

Bush

THE WHITE HOUSE

EXECUTIVE OFFICE OF THE PRESIDENT
COUNCIL ON ENVIRONMENTAL QUALITY
722 JACKSON PLACE, NW
WASHINGTON, DC 20503

Letter of Transmittal

The President:

Sir: The Council on Environmental Quality herewith submits its Environmental Quality Report for the years 1987 and 1988 in accordance with section 201 of the National Environmental Policy Act of 1969 (42 U.S.C. 4341).

Respectfully,

A. Alan Hill

A. Alan Hill
Chairman

William L. Mills

William L. Mills
Member

Jacqueline E. Schafer

Jacqueline E. Schafer
Member

Preface

Environmental Quality 1987-1988, the annual report of the Council on Environmental Quality, is being published in fulfillment of the Council's reporting requirements under the National Environmental Policy Act of 1969 (P.L. 91-190, 42 U.S.C. 4341) ("NEPA"). This report combines in one document an account of the activities of the Council and the developments under the National Environmental Policy Act for the calendar years 1987 and 1988.

In setting forth the current status of the major environmental classes of the Nation, this environmental quality report focuses on selected environmental conditions that are largely "manmade" and includes chapters on urban air quality, developed water resources and municipal solid waste; it also includes a chapter on the management of natural resources and environmental protection at defense installations, where conditions are affected by highly specialized and often intensive land uses. Appendix B includes a chapter on the latest legal and administrative developments under the National Environmental Policy Act. All chapters provide current information through calendar year 1988.

This environmental quality report also includes a comprehensive set of statistical tables that corresponds to a forthcoming edition of CEQ's *Environmental Trends* sourcebook. The printing of this book of maps, charts and graphs is scheduled for later in 1989, but the data are set out here in tabular form in Appendix C. Appendix C has been revised since the Council's previous annual report for 1986 and includes data for 1987 where available. The Council expects to continue to update these tables as new data become available.

Acknowledgments

The Council on Environmental Quality would like to acknowledge and thank those individuals who prepared papers for our use in drafting chapters for this report: Dr. Kay Jones, PhD, Vice President of Roy F. Weston, Inc. ("Ozone Status and Trends"); Larry J. Silverman, Esq. ("Solid Waste on the Land"); Morgan Rees, John Belshe, Eugene Stakhiv, and Martin Reuss ("Developed Water Resources and the Environment"); and Christina Ramsey, Director for Environmental Planning, Office of the Secretary of Defense ("Defense Department Environmental Programs"). We are also indebted to the following individuals for their assistance in compiling the chapter on water resources: Carl Brown, William Burris, John Bushman, Dave Hewitt, Jessie Pfeiffer, Robert Pierce and Paul Rubenstein (Department of the Army); David Ketchum, Larry Schmidt and Howard Tankersley (Department of Agriculture); John Anderson and Marlowe Teuscher (Department of the Interior). The illustrations are by Robert P. Adams.

We appreciate the efforts of other federal agencies in reviewing and providing comments and additional material for the chapters, including the Environmental Protection Agency, the Bureau of Reclamation and the Soil Conservation Service. We would also like to thank following members of the staff of the Office of Environmental Quality: Lucinda L. Swartz (Appendix A, Activities of the Council), Dinah Bear and Edward Yates (Appendix B, National Environmental Policy Act), and Sara D. Nero and Lynne Grant Mohr, for their support in the production of the report. The statistical tables (Appendix C) were prepared for the Council under a contract with Carroll Curtis of the Virginia Institute of Marine Science at the College of William and Mary, and were reviewed by the agencies identified as the source of the data. Council Member Jacqueline E. Schafer prepared and edited the report based on the papers supplied by the individuals named herein.

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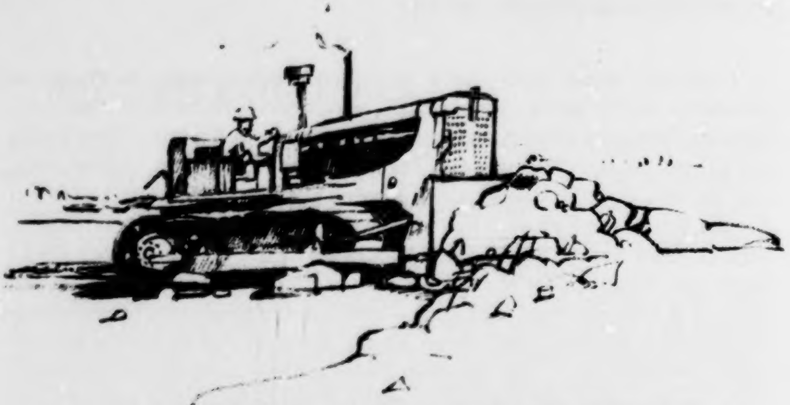


Municipal Solid Waste

1

Take your refuse elsewhere or you will be fined.

– Inscription on an ancient Roman signpost.[1]

The idea of waste carries with it images of poverty and plenty. In the old English common law waste was a kind of mismanagement of land and estates which, while it may have benefitted the current occupant, left the estate and its future tenants much poorer. It is an invasion or a squandering of capital.

> Waste: . . . Spoil or destruction, done or permitted, to lands, houses, gardens, trees, or other corporeal hereditaments, by the tenant thereof, to the prejudice of the heir, or of him in reversion or remainder. . . . Any unlawful act or omission of duty on the part of the tenant which results in permanent injury to the inheritance. . . . *Black's Law Dictionary*

President Theodore Roosevelt decried waste of this sort in his efforts to conserve our nation's natural resources.

> To waste, to destroy, our natural resources, to skin and exhaust the land instead of using it so as to increase its usefulness, will result in undermining in the days of our children the very prosperity which we ought by right to hand down to them amplified and developed.[2]

Ironically, some waste, such as post-consumer waste, is a sign of prosperity. In the world's poorer cities, scavengers form an important component of the solid waste management system. Here in America, these trades are all but forgotten. The once familiar song of the city rag man, "Any old rags, any old bags, any old bottles today," is only a memory of the older half of our people. Products which once had salvage value are now thrown away. Others, such as paper tissues, napkins and diapers are meant to be discarded after a single use. Replacement of small appliances and gadgets is often easier and cheaper than repair. And packaging – which has enhanced the marketability of consumer products, has added greatly to safety and sanitation and extended product life – has also contributed to the growth of the trash heap. Such conveniences are sometimes called "labor-saving," and indeed many consumer products have become a substitute for another important resource – human energy, time and creativity – which has been released for work elsewhere. As a result, society is safer, healthier and people live longer and more enjoyable lives.

Yet, America as a nation is filling landfills faster than it can site new ones. Per capita waste production in the United States is greater than in any country in the world. Collectively, this nation productes 160 million tons of garbage a year, and one-half of the municipal landfills in this country will be full by the mid-1990s. Furthermore, our expectations concerning the aesthetic and environmental quality of our surroundings has increased along with our general prosperity.

In his environmental message to Congress in 1972, President Richard M. Nixon suggested that improved solid waste management would include taking advantage of missed opportunity:

> Recycling – the technique which treats many types of solid waste not as pollutants but as 'resources out of place' – is an important part of the answer to the Nation's solid waste burden.

There are many obstacles to realizing the resource potential of the garbage heap. Nonetheless, as will be seen, the list of projects, industries and communities that have overcome these obstacles is growing. In some instances, the recovery of resources from trash is profit driven. In others the goal is to reduce the rapidly escalating cost of safe waste disposal by waste avoidance and energy and material recovery.

While our public policies must be rooted in economic realism and our regulations crafted so as to protect health and the environment in as cost effective a way as possible, governmental responses are only part of the solution to improving the visual landscape and environmental quality of our developed communities. A sense of values, an abiding concern for America's inheritance, is an indispensable component of a waste management program that amplifies rather than undermines the prosperity we pass on.

Conditions and Trends

Americans are producing more solid waste than ever in our history and have fewer places to put it. This problem was dramatized in the spring of 1987 by the long voyage of the garbage scow Break of Dawn, which wandered the Atlantic Ocean for weeks, like a modern day Flying Dutchman, in a vain search for a place to unload its cargo of domestic waste from Long Island.

Behind the sensational voyage are some sobering statistics. In 1960, Americans generated municipal type solid waste at the rate of 2.65 pounds per person per day. By 1986, that figure had climbed to 3.58 pounds, and the trend is up.[3] Americans generate approximately one pound per person per day more garbage than their counterparts in West Germany, an equally industrialized nation.[4] In gross terms, American municipal waste production has grown from 87.5 million tons per year in 1960, to 157.7 million tons in 1986, enough to fill a convoy of 10 ton garbage trucks, 145,000 miles long, which is over half the distance between earth and the moon.[5]

While the amount of trash has grown, facilities to handle it have become scarcer. In 1978, there were approximately 20,000 municipal landfills in operation. Today, less than 6,000 are still in use. By 1993 about a third of these will be filled. Many more will be closed due to inadequate safety or environmental practices as new standards take effect. Some states such as Florida, Massachusetts, New Hampshire and New Jersey are expecting to close just about all of their currently operating landfills in the next ten years.

The number of new facilities being opened is declining. In the early 1970's roughly 300 to 400 new municipal landfills were being opened each year. During the last ten years, this number has dropped to between 50 and 200 new landfills per year, without a corresponding increase in landfill size to compensate for lost capacity.[6]

A large number of existing solid waste landfills do not meet current federal and state standards for safe design and operation. For example, only 25 percent of currently operating municipal landfills monitor groundwater for possible pollution.[7] Less than 16 percent have natural or artificial liners. Only 5.2 percent collect the polluted leachate or liquid waste which is produced when liquids percolate through the refuse. Only half of these treat the leachate they collect. More than half of municipal landfills make no attempt to control water pollution resulting from the runoff of rain water from their sites. Less than half impose restrictions on receipt of bulk liquid wastes.[8] These and other practices suggest that a large portion of landfilled municipal solid waste ends up in places where it might contaminate groundwater.

Twenty-two percent of the sites on the Superfund National Priorities List, which includes the sites posing the greatest chemical hazards to public health and the environment, are municipal waste landfills.[9] Most of these were developed prior to the imposition of state and federal regulations, and often received wastes that today are considered hazardous. Thousands of other landfills, mostly closed, are being investigated for similar problems. Uncertainty exists as to the overall risk to health and the environment posed by landfills. Unfortunately, there is a paucity of peer reviewed and generally accepted scientific studies on this subject. An assessment performed by the U.S. Environmental Protection Agency (EPA) to estimate the relative risk reduction associated with different alternatives for regulating landfills suggests that if solid waste landfills continued to operate under current federal regulations, the cancer risk would average fewer than 0.08 cases per year.[10]

The siting of new waste facilities and the choice of waste processing technologies have ignited heated controversies in almost every city and county in the land. Some of the controversy is just an outgrowth of the so-called NIMBY, or not-in-my-back-yard phenomenon. Much of it grows out of concerns or uncertainties about the side effects of technologies and the inadequacies of regulation. While there has been no single incident that has attracted the attention of the nation, the large number of local controversies is bringing the issue of municipal waste facility siting and technology choice home to the American people.

The cost of trash disposal is going up. Throughout America's history the price of disposing of the trash hardly registered on the average family budget. As late as 1982, most American municipalities were spending less than 0.5 percent of their municipal budgets on solid waste disposal. This compares with 36 percent for education, 5 percent for police protection, 3 percent for sewage disposal and 2 percent for fire protection.[11] This is beginning to change. For example, in 1987, Newark, New Jersey paid out $6 million for waste management. By 1988, the cost had skyrocketed 500 percent to $30 million. The average family trash bill rose from $7.33 per month to $33.00 per month in less than a year's time.[12]

Not all cities have experienced such dramatic cost increases. The ultimate shape of the cost curve for municipal waste remains to be determined. However, the Institute for Local Self Reliance projects that landfilling costs in East Coast and Midwestern cities will grow at the rate of 15 percent per year over the next five years.[13] In 1979, the cost of collecting the garbage was about nine times greater than the cost of disposal. Today, collection costs are only twice the amount of disposal costs; in some cities they are the same.[14]

Another indicator of rising costs is the so-called "tipping fee." This is the per ton price that haulers of trash pay to landfills and incinerators to take it. The price does not equal the costs to the economy of trash disposal. Most solid waste facilities are subsidized in a variety of ways, many of them hidden. Nonetheless, trends in tipping fees do suggest the direction of overall costs. Based on six annual surveys of tipping fees at landfills and incinerators, or "resource recovery" facilities, the average national refuse disposal cost rose 73.5 percent between 1982 and 1987.[15]

Table 1. Average tipping fees, 1982-1987, for the national sample.

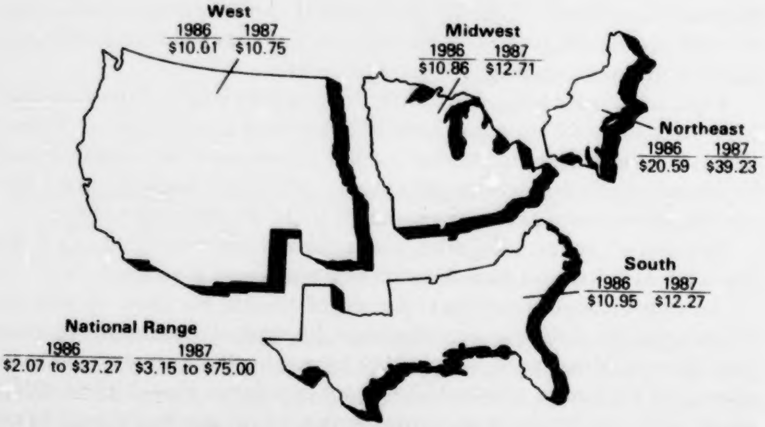
YEAR	LANDFILL	RESOURCE RECOVERY
1982	$10.80	$12.91
1983	$10.80	$14.98
1984	$10.59	$17.26
1985	$11.93	$23.17
1986	$13.43	$30.42
1987	$20.36[1]	$33.64

[1] Some of the large increase between 1986 and 1987 can be attributed to the addition of sites in areas with very high fees (e.g., Massachusetts).

Source: *Waste Age*, National Solid Waste Management Association, Washington D.C., March 1988

The issues discussed above apply mainly to the small sector of the solid waste stream known as municipal solid waste, or, in the jargon, MSW. This refers primarily to residential solid waste, with some contribution from commercial, institutional and industrial sources. In general MSW includes all the stuff collected by municipal sanitation agencies.

Figure 1. Regional Tipping Fee Averages for Landfills.


West
1986 $10.01
1987 $10.75
Midwest
1986 $10.86
1987 $12.71
Northeast
1986 $20.59
1987 $39.23
South
1986 $10.95
1987 $12.27
National Range
1986 $2.07 to $37.27
1987 $3.15 to $75.00

Source: *Waste Age.* National Solid Waste Management Assoc., Washington, D.C. March 1988.

Most solid waste, however, is industrial, agricultural and mining. Municipal type wastes are estimated at 160 million tons. Industrial wastes are measured in the billions of tons. The Environmental Protection Agency estimates that industries generate 7.6 billion tons per year of solid waste that is classified as nonhazardous (which includes about 55.8 million tons of electric utility wastes). Oil and gas producers generate two to three billion tons per year; mining operations about 1.4 billion tons. Some of these waste materials, especially mining wastes, utility wastes and oil and gas wastes are the subjects of ongoing studies by the EPA under authority of section 8002 of the Resource Conservation and Recovery Act. For the most part, the non-municipal wastes are located in some 220,000 separate facilities. The vast majority of these industrial waste facilities are unlined surface impoundments. Large numbers of industrial waste heaps may also be found in the United States, although no official estimate of the actual number has been made.[16]

The major issues of municipal solid waste today are a growing amount of waste and a diminishing number of waste management facilities; waste materials showing up where they do not belong; great uncertainty and controversy about the siting of waste facilities and the choice of technology; rapidly escalating costs; and the troubling prospect of unknown and perhaps unsafe depositories of industrial solid waste.

Constituents of the Rubbish Heap: Material Waste

One hundred years ago, 75 percent of urban waste consisted of ashes from fire places and coal stoves.[17] The ash can, in some regions, is still synonymous with the trash can. But the contents of the trash can have changed dramatically, and are likely to change again before the century is over.

Paper and cardboard comprise fully 41 percent by weight of the municipal solid waste stream. The second heaviest component is yard waste, at 18 percent. Glass; metals; plastics; leather, textiles, rubber and wood combined; and food wastes weigh in at smaller percentages of the total, ranging from 6.5 percent for plastics to 8.7 percent for metals.[18] [19, 20] See figures 2 and 3.

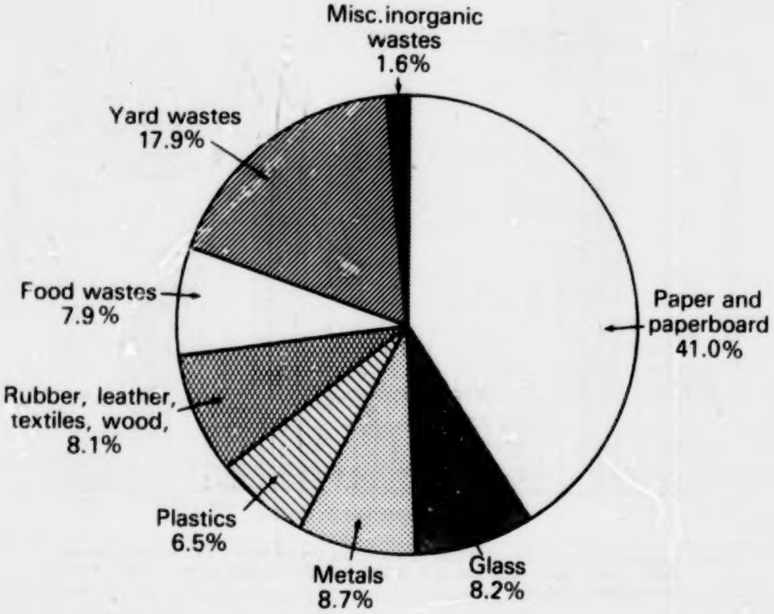
In terms of product categories, packaging and containers make up more than a third of all wastes. Non-durables comprise about 26 percent.

An anthropologist from the University of Arizona has come up with the following weight and volume correlations in his study of the actual contents of particular landfills: paper, 34.5 percent by weight, 45.5 percent by volume; plastic, 4.8 percent by weight, 16.3 percent by volume; glass, 2.4 percent by weight, 0.9 percent by volume; ferrous metals, 4.8 percent by weight, 2.8 percent by volume; aluminum, 0.8 percent by weight, 1.1 percent by volume.[21]

The Environmental Protection Agency notes that the people actually handling the wastes report that the volume of MSW is growing faster than the weight. (This may account, in part for the growing popularity of incineration, which reduces weight only by 70 percent, but causes a much greater reduction of volume.)

The EPA has also noted the following historical trends in garbage generation. Paper, plastics and aluminum have been growing as percentages of total

Figure 2. Gross Discards of Municipal Solid Waste Materials, 1986, by Percentages.

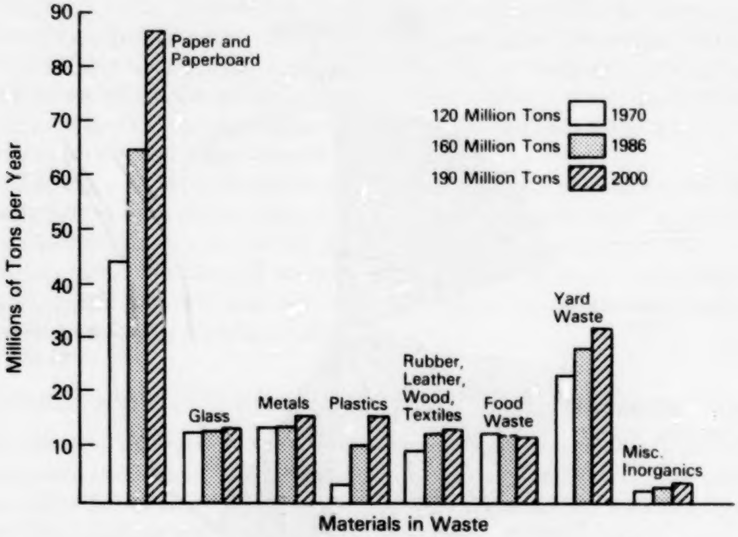


Source: Characterization of Municipal Solid Waste in the United States, 1960 to 2000 (Update 1988). Franklin Associates, Ltd. U.S. Environmental Protection Agency, Office of Solid Waste, March 30, 1988.

municipal solid waste, while glass and steel – relatively heavy materials – have been declining. Durable goods (appliances, furniture, tires) have remained flat in percentage terms, while non-durables have increased steadily. Within the non-durables category, newspapers have stayed constant, but office papers and commercial printing papers have been growing. This reflects the growing flow of computer printouts, instant copiers and direct mail advertising.

In the home, paperboard cartons and plastic jugs have replaced glass milk bottles; aluminum beverage cans have replaced steel; plastic soft drink bottles have replaced glass in the larger sizes; plastic food jars are beginning to replace glass; and plastic bags are replacing paper. Indeed, plastic appears to be our fastest growing discard.[22]

Figure 3. Gross Discards of Materials in Municipal Solid Waste by Tonnage.



Source: Characterization of Municipal Solid Waste in the United States, 1960 to 2000 (Update 1988). Franklin Associates, Ltd. U.S. Environmental Protection Agency, Office of Solid Waste, March 30, 1988.

Following is a very brief summary of some of the central issues and trends for the major components of the waste stream:

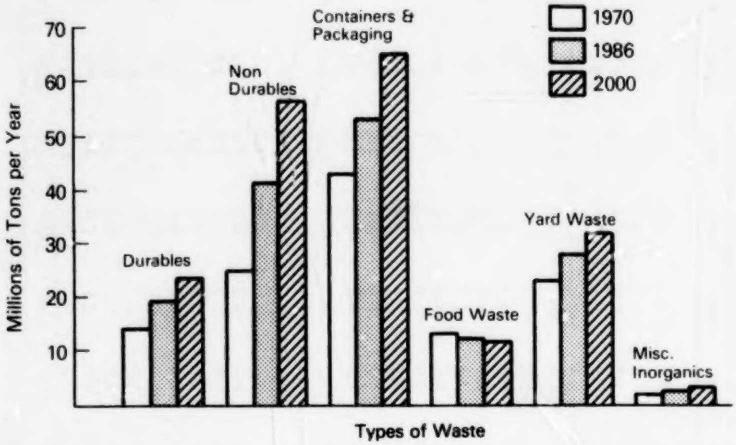
Paper

In 1986, Americans recycled about 28 percent of the paper produced. This percentage is about equal to the percentage achieved in 1955. Sixty-three percent of all paper produced in 1986 ended up in landfills and incinerators. The remaining nine percent was either permanently stored in books, records and building materials, or otherwise disposed of.

The American rate of paper recycling is about half of that of other industrialized nations. A significant portion of America's waste paper, especially corrugated cardboard, is exported to Mexico and the Asian rim countries where it is refabricated.

Paper recycling, for home consumption and exports, is on the rise. Figures for 1987 and 1988 are expected to show significant increases. The capacity of

Figure 4. Products Discarded into the Municipal Waste Stream by Percent.



Source: *Characterization of Municipal Solid Waste in the United States, 1960 to 2000 (Update 1988).* Franklin Associates, Ltd. U.S. Environmental Protection Agency, Office of Solid Waste, March 30, 1988.

American paper mills to use waste paper is also increasing slowly, from 24.5 percent of total fiber in 1986, to 25.4 percent in 1989.[23] Unfortunately, in slow economic periods, recycle capacity is often idled before virgin capacity because these mills – often older and smaller – become uneconomical faster and tend to be used to produce products which are more sensitive to economic ups and downs.

A growing number of American communities are collecting paper, especially newspapers, for recycle. Given the tremendous contribution of paper to the trash stream, both in terms of weight and volume, separate collection and recycling becomes increasingly attractive to hard pressed municipalities. Indeed, activity on the local and state level in this area is growing so rapidly that any catalogue would be obsolete before this report reached print.

Paper products burn readily and lend themselves well to incineration as well as recycling. Paper accounts for about 50 percent of the heat content of an average ton of municipal solid waste.[24] In many communities, conflicts exist as to which type of facility gets to keep the paper. According to one recycling advocate, communities with large burning facilities generally recycle less than 3 percent of household waste paper.[25] Proponents of incineration argue that recycling half of all newspapers and corrugated cardboard boxes

Table 2. Products discarded into the municipal waste stream (in percent of total discards).

PRODUCTS DISCARDED	1960	1965	1970	1975	1980	1981	1982	1983	1984	1990	1995	2000
Durable Goods												
Major Appliances	1.9	1.1	2.4	2.2	2.1	2.2	2.2	2.1	2.0	1.7	1.7	1.1
Furniture and Furnishings	2.7	2.9	3.1	3.6	4.1	4.1	4.7	4.8	4.4	4.5	4.7	5.1
Rubber Tires	1.0	1.1	1.4	2.1	1.9	1.8	1.6	1.2	1.0	1.1	1.1	1.1
Miscellaneous Durables	6.0	5.9	5.7	6.2	6.1	6.1	6.6	6.4	6.5	6.8	6.5	6.4
TOTAL DURABLES	11.8	10.9	12.6	14.1	14.2	14.2	15.1	14.5	14.0	14.1	13.8	14.2
Nondurable Goods												
Newspapers	6.9	6.8	6.5	5.6	6.5	6.6	6.1	6.3	6.7	6.7	7.0	7.2
Books and Magazines	2.4	2.3	2.0	1.8	2.4	2.5	2.6	2.9	3.2	3.4	3.9	4.2
Office Papers	1.7	2.0	1.8	1.7	2.5	2.4	2.5	2.7	2.9	3.2	3.5	3.8
Commercial Printing	1.4	1.7	1.6	1.6	2.1	2.1	2.2	2.4	2.7	3.0	3.3	3.7
Tissue Paper and Towels	1.4	1.6	1.9	1.9	1.9	1.9	1.9	2.0	2.1	2.1	2.1	2.1
Other Nonpackaging Paper	3.7	4.5	3.5	3.3	3.6	3.7	3.5	3.9	4.0	3.9	3.9	4.1
Clothing and Footwear	2.0	1.8	1.6	1.8	2.1	2.1	2.1	2.1	2.0	2.0	2.1	2.1
Other Miscellaneous Nondurables	0.5	0.5	0.7	0.9	1.9	1.9	1.9	1.9	2.0	2.2	2.4	2.6
TOTAL NONDURABLES	20.1	21.3	19.6	18.6	23.0	23.2	22.8	24.2	25.6	26.9	28.4	29.8
Containers and Packaging												
Glass												
Beer and Soft Drink Bottles	1.7	2.7	4.9	5.2	4.8	4.7	4.6	4.3	3.7	3.2	2.9	2.6
Wine and Liquor Bottles	1.2	2.5	1.7	1.8	1.9	1.9	1.8	1.8	1.7	1.6	1.4	1.3
Food and Other Bottles and Cans	4.8	4.6	4.0	3.9	3.8	3.8	3.8	3.6	3.6	3.2	3.0	2.8
Total Glass	7.7	8.7	10.6	10.8	10.5	10.4	10.2	9.5	8.9	8.0	7.4	6.8
Steel												
Beer and Soft Drink Cans	0.8	1.0	1.4	1.1	0.4	0.2	0.2	0.1	0.1	0.1	0.1	0.1
Food and Other Cans	4.8	3.9	3.2	2.9	2.3	2.0	2.0	1.9	1.9	1.7	1.4	1.2
Other Steel Packaging	0.4	0.3	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1
Total Steel	6.0	5.1	4.8	4.2	2.7	2.5	2.3	2.1	2.1	1.9	1.6	1.4

Table 2. (cont.) Products discarded into the municipal waste stream (in percent of total discards).

PRODUCTS DISCARDED	1960	1965	1970	1975	1980	1981	1982	1983	1984	1990	1995	2000
Aluminum												
Beer and Soft Drink Cans	0.1	0.1	0.3	0.4	0.5	0.4	0.4	0.4	0.5	0.5	0.5	0.6
Other Cans	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1
Foil and Closures	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3
Total Aluminum	0.2	0.3	0.5	0.6	0.7	0.6	0.6	0.7	0.7	0.8	0.9	0.9
Paper and Paperboard												
Corrugated Boxes	6.2	8.4	8.8	8.4	8.0	8.8	8.0	8.3	8.9	9.0	9.7	10.2
Other Paperboard	4.6	4.5	3.9	3.4	3.5	3.3	3.4	3.5	3.7	3.4	3.3	3.1
Other Packaging	3.5	3.4	3.1	2.6	3.0	3.0	3.0	3.1	3.0	2.9	2.8	2.4
Total Paper	14.4	16.2	15.8	14.4	14.5	15.1	14.4	14.9	15.6	15.3	15.7	15.8
Plastics												
Plastic Containers	0.1	0.3	0.8	1.2	1.7	1.6	1.6	1.7	1.8	2.1	2.3	2.5
Other Packaging	0.1	0.8	1.1	1.3	1.7	1.8	1.8	1.9	1.9	2.2	2.5	2.7
Total Plastics	0.2	1.1	1.9	2.4	3.4	3.4	3.3	3.5	3.7	4.3	4.8	5.2
Wood Packaging	2.6	2.3	1.9	1.8	1.7	1.6	1.6	1.5	1.5	1.4	1.3	1.3
Other Miscellaneous Packaging	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2
TOTAL CONTAINERS AND PACKAGING	31.6	33.7	35.6	34.3	33.6	33.8	32.7	32.5	32.7	32.2	32.0	31.6
TOTAL NONFOOD PRODUCT WASTES	63.4	65.9	67.9	67.0	70.8	71.2	70.6	71.6	72.2	73.3	74.6	75.9

Table 2. (cont.) Products discarded into the numicipal waste stream (in percent of total discards).

PRODUCTS DISCARDED	1960	1965	1970	1975	1980	1981	1982	1983	1984	1990	1995	2000
Other Wastes												
Food Wastes	14.7	13.1	11.5	11.8	9.3	8.9	8.8	8.5	8.1	7.6	7.3	6.8
Yard Wastes	20.3	19.2	19.0	19.4	18.2	18.1	18.7	18.0	17.9	16.8	16.1	15.4
Miscellaneous Inorganic Wastes	1.7	1.7	1.6	1.8	1.8	1.8	1.9	1.8	1.8	1.9	1.9	1.9
TOTAL OTHER WASTES	36.6	34.1	32.1	33.0	29.2	28.8	29.4	28.4	27.8	26.7	25.4	24.2
TOTAL WASTES DISCARDED*	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
ENERGY RECOVERY**	—	0.2	0.4	0.6	2.2	1.8	2.9	3.8	4.9	9.4	15.0	20.0
NET WASTES DISCARDED	100.0	99.8	99.6	99.4	97.8	98.2	97.1	96.2	95.1	90.6	85.0	80.0

* Wastes discarded after materials recovery has taken place.

** Municipal solid waste consumed for energy recovery.

Details may not add to totals due to rounding.

Source: Franklin Associates, Ltd.

would cause only a 3 percent decrease in heating value per pound of municipal solid waste.[26] The New York State Department of Environmental Conservation now requires that a recycling program be part of any waste-to-energy facility.

A major, although not thoroughly understood, problem with both incineration and recycling is the presence of toxic chemicals in inks and other processing chemicals. In addition, certain paper making processes using chlorine result in papers with small quantities of dioxin.[27]

Paper is also biodegradable and disappears from the environment rather rapidly. Most paper litter is of very recent vintage. In landfills, however, where the waste is compressed and kept away from oxygen and water, paper products experience little, if any degradation.

Glass

There appear to be only two economic approaches for managing waste glass: reuse and recycle, and landfilling. Glass is a detriment to the waste incineration process. It does not burn, it is abrasive to the equipment and it tends to form into slags.

More than 90 percent of the glass in the municipal solid waste stream is container glass, primarily beverage containers and food jars. The average American discards about a quarter of a pound of glass a day.[28] The Worldwatch Institute estimates that more than half the glass produced in the United States is manufactured into products with life spans of less than one year.[29]

The problems of glass waste management are a function of glass industry economics. Many Americans still remember the day of the refillable glass container, a day that has all but passed from the American scene. Refillable bottles are considerably heavier than one-way glass, aluminum or plastic containers. The key to their economics was a decentralized bottling industry, which tended to minimize transportation costs. Refillables made good business sense when the needs of the nation were serviced by close to 3,000 bottlers. Today there are only 300, an economic development that has had an adverse impact on solid waste management.[30]

The demise of refillables in the U.S. contrasts sharply with the pattern that has emerged in Japan, where for example 95 percent of beer bottles and 2-liter sake bottles are reused up to 20 times.[31]

Glass in the solid waste stream experienced dramatic growth from 1960 through the mid 1970's, when it began a slow decline. Between 1960 and 1973, discards of glass beer and soft drink containers grew from 1.4 million tons a year to 6.1 million tons, more than a fourfold increase. Wine and liquor bottles in the trash heap more than doubled, from 0.9 million tons to 2.1 million. Other glass containers grew from 3.7 to 4.4 million tons. The emergence of plastic and metal containers caused a leveling off of glass waste beginning in

Table 3. Proportion of complete bottles reused in Japan (FY 1983).

ITEMS	QUANTITY USED (1,000s)	QUANTITY COLLECTED (1,000s)	PERCENTAGE OF BOTTLES REUSED	AVERAGE NUMBER OF TIMES REUSED
2-liter sake bottles	7,830	7,440	95	20.0
Beer bottle	608,970	578,520	95	20.0
Juice bottle	274,000	250,890	91	11.1
1.8-liter sake bottle	122,250	102,690	84	6.3
Soda bottle	332,000	258,400	78	4.5
Yogurt	11,300	2,030	18	1.2
Soy sauce	32,500	5,530	17	1.2
Domestic whiskey bottle	61,810	8,040	13	1.1
Middle- and small-size sake bottles	76,400	8,300	11	1.1
Medicinal drink bottle	281,500	0	0	1.0
Instant coffee bottle	31,980	0	0	1.0
Imported whiskey bottle	7,800	0	0	1.0
Total	1,848,440	1,221,840	66	2.9

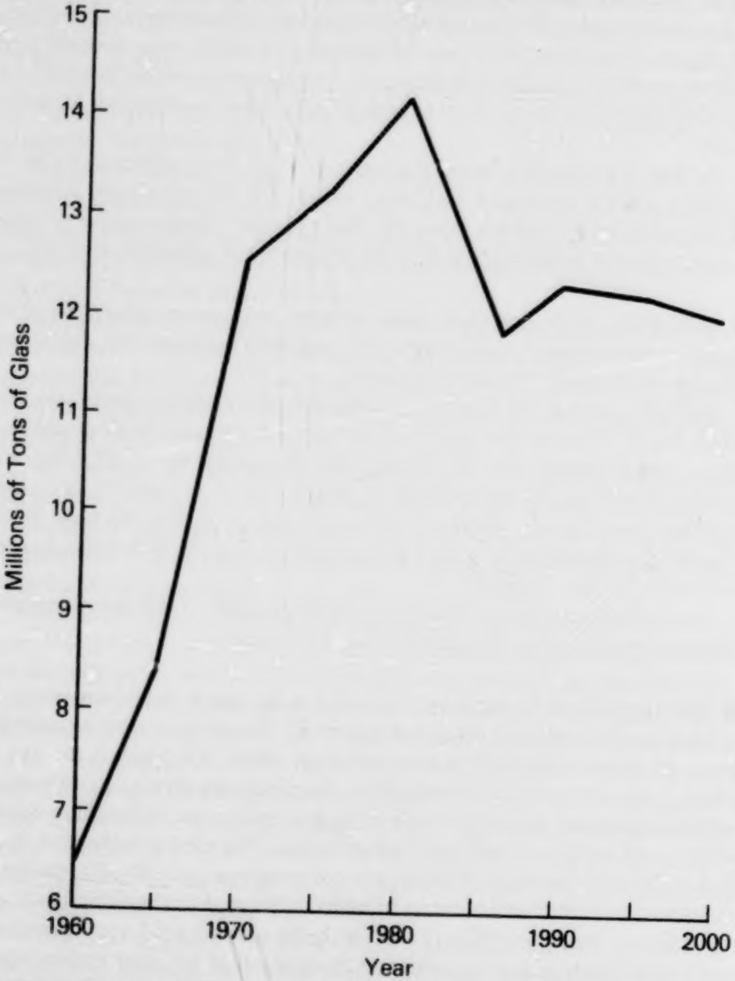
Source: Japan Bottles Association

1980.[32] As we enter the 1990's the trend in waste glass may once again be on the rise, as is the use of glass containers.[33]

In 1986 and 1987 the glass container industry showed evidence of a resurgence, due largely to consumer preferences based on glass' image of purity and prestige, suitability for microwave ovens, barrier properties and ability to be recycled.[34] According to the Department of Commerce, glass container shipments in 1987 rose by 3.5 percent above 1986 shipments. *The Nickel Solution News*, a recycling paper, projects a 2.6 percent increase in glass container shipments in 1988, and 3 percent annual increases during the period from 1988 to 1993.

Cullet, or crushed waste glass, appears to be the key to glass reuse in the United States today. The use of cullet by the glass manufacturing industry has grown dramatically from 24,000 tons a year in 1970 to more than a million tons today.[35] Almost any glass factory can use a certain amount of cullet as feedstock. This contrasts sharply with paper manufacturing facilities, which must be specially designed to accept waste paper. Cullet is a highly desirable component of the mix going into the glass furnace. Cullet melts at a lower temperature than the other raw materials for glass, such as silica, and facilitates their melting. Advantages of mixing in cullet include energy savings, a reduction in air emissions and an extension of the life of the furnaces' refractory linings. The net result comes down to this: *if a reliable supply of good quality cullet can be delivered to America's glass factories*, America's glass industry can make use of it without substantial modification of its infrastructure. These are big if's. The questions of reliability, quality and transportation are very large.

Figure 5. Actual Glass Discarded into Municipal Waste Stream.



Source: Characterization of Municipal Solid Waste in the United States, 1960 to 2000 (Update 1988). Franklin Associates, Ltd. U.S. Environmental Protection Agency, Office of Solid Waste, March 30, 1988.

■ **Quality:** "Furnace ready" cullet for container manufacturers must meet fairly detailed specifications. Color sorting and purity, (which in this case means absence of unwanted or "tramp" materials such as paper, plastic, metals, dirt, ceramics and so forth) are critical factors for bottle and jar makers. On the other hand, fiber glass, insulation, "glassphalt" (a kind of paving material) and building material manufacturers can more readily accept a mixed batch of cullet. This market, however, is not as large or as lucrative as container manufacturing.

A few communities have demonstrated an extraordinary ability to produce a color separated and clean cullet. For the most part, however, municipalities have not yet taken the many material steps needed to move from a system of collection and disposal to a system of collection and sale.

■ **Reliability:** Although most glass furnaces can accept cullet, they react poorly to rapid changes in the mix of cullet and other raw materials. This means that the industry requires a reliable supply.

In recent years about a dozen states have enacted bottle deposit laws. The effect was to increase the supply of sorted beer and soft drink containers. Many people hoped that this would solve the problems of reliability and quality. However, the mix of glass to plastic and aluminum began to shift rapidly in the deposit states, creating uncertainty in the industry. While deposit laws may have increased glass recycling, the actual increase has not yet lived up to the potential.

It is still too early to evaluate the overall reliability of municipal trash entities as suppliers of raw material for the glass industry.

■ **Transportation:** Glass factories tended in the past to locate near deposits of high quality sand and other raw materials. These are not necessarily the areas of greatest population concentration, where the greatest amount of waste glass may be found. New facilities for producing glass from mixtures of cullet and sand are not surprisingly springing up in areas, such as New Jersey, where sand and population are both plentiful. This ideal combination is not typical. In many instances the savings in costs and energy realized by the use of cullet may be neutralized or worse by added transportation requirements.

A glass industry that offers a solution to the nation's solid waste problems, and a solid waste system that services basic needs of the glass makers is still only a goal, an ideal. The challenge for policy makers and government is to encourage both sides to reach appropriate accommodations in individual cases which incorporate the service ethic of municipal systems and the economic efficiencies of the private sector.

Food Waste

America scrapes about 12 and a half million tons of food wastes off its plate each year and into the garbage can. This number has stayed more or less constant over the last 30 years. However, the percentage of the waste stream occupied by food has been in slow decline, as we have discovered ever new ways to make waste. In 1960, 12.2 million tons of scraps accounted for 14.9 percent of the waste stream. By 1986, about the same quantity, 12.5 million tons, accounted for only 8.9 percent.[36]

The word "garbage" comes from the French word for entrails, and once referred exclusively to food wastes. It may be fitting that the word has come to stand for the entire household waste stream, since food wastes evidence two of the most objectionable characteristics of solid waste, namely a tendency to putrefy rapidly and to attract vermin.

Most food waste, like most trash, ends up in landfills. There it contributes to formation of leachate and methane gas, both of which are generally undesirable. Food wastes will burn in incinerators, although their heat content is so low and their moisture content so high that they generally detract slightly from the incinerator's performance.

An unknown but probably large amount of food wastes are disposed of into kitchen garbage grinders. The impact of this on municipal sewage systems is in some dispute. Widespread agreement exists however that garbage grinders detract from the performance of home sewage systems composed of septic tanks and leach fields.

In the past, urban food wastes were collected separately and fed to rural hogs. This practice was mostly abandoned as health officials began to insist that the garbage be cooked before giving it to the animals, as collection costs began to rise and as cities began to encourage kitchen sink garbage grinders. The system of feeding food wastes to animals still has viability in special situations. About 50 farmers in New Jersey are now feeding their hogs food scraps from the restaurants along the Jersey shore. The food, about 1,500 tons a week, is steamed and mixed with grain.[37] An ice cream manufacturer in central Vermont solved the problem of its overloaded local sewage plant by diverting waste that used to go down the drain to its own hog farm, purchased for the purpose of waste disposal.

Many rural and suburban homeowners maintain their own garden compost piles, a practice that some state and local governments (including Portland, OR, Seattle, WA, and the states of Wisconsin and California, among others) actively encourage by educational programs.[38]

The good news about food waste is that we throw away a lower portion of our edibles than did our grandparents. The modern American family ends up trashing about ten percent of its food, not counting bones, tops, peels and rinds. In 1918, the percentage was closer to 25 percent.[39] This is a tribute to modern packaging, processing and refrigeration.

Yard Wastes

Yard wastes, including grass clippings, autumn leaves, tree prunings and the like, comprise a remarkably large fraction of municipal solid waste. In 1986, municipal systems collected and disposed of 28.3 million tons of yard waste. This was more than one fifth of the total municipal solid waste that year. Quantities and types of yard waste vary widely from year to year and region to region. But yard wastes are a major component of the national trash pile everywhere. Indeed, the very word "trash" comes from a Norwegian word "trask," meaning the discarded trimmings from wood cutting operations.

If in the distant past, all trash was yard waste, in the near future most yard waste may be excluded from the trash pile. The State of New Jersey, whose solid waste problem is severe, has banned yard wastes from the state's hard pressed landfills and incinerators as of September 1988. New York and Minnesota are planning similar bans. Yard waste occupies a great deal of space in landfills and contributes significantly to methane generation and leachate production. While yard waste can be and is being successfully incinerated, it has a low heating value and can often aggravate incinerator air pollution problems. Grass clipping and wet leaves are especially problematic for trash burners.[40]

Separation of yard waste from other solid waste is relatively easy. Most of it comes from suburban lawns and gardens.[41] Yard wastes can be converted with relative ease to compost and other soil conditioners or mulches, which can then be sold or given away to the public; sold to garden and plant shops and sod farms; used in public parks and gardens and landscaped portions of highways; and used for daily cover in landfills.

Examples of successful yard waste compost programs are varied and numerous. San Mateo, California composts about 41,000 cubic yards of material a year at the site of a closed construction debris landfill. The aim is to convert the 35 acre site on the shores of San Francisco Bay into a public park. Seven years of operation will cover the site with about a foot of compost, a topsoil like material ideal for parkland. At a seven year net cost of $200,000, the city expects to save three million dollars in park development costs.[42]

Successful yard waste composting programs are still the exception. The predominate practice is to landfill these bulky and difficult to handle materials. As landfill space becomes scarcer, more and more communities are likely to turn to composting.

Aluminum

In the past, the use of aluminum as a packaging material provoked a good deal of criticism from environmental advocates, due to the large energy and environmental costs associated with its manufacture and disposal. Today the high energy cost of aluminum is one of the foundations for the most extensive and successful recycling program in America. Producing a new aluminum can from a recycled old one uses only five or ten percent as much energy.[43] Fully 50.5 percent of the aluminum cans produced in the U.S. are recycled.[44]

Perhaps most significant reason for this success is the structural changes the aluminum industry has undergone since embarking on a serious recycling program in the early 1970's. Domestic production of the metal from ore has remained fairly flat or declined in recent years. But production from scrap has been flourishing. Between 1970 and 1983, the percentage of aluminum produced from recycled material in the U.S. rose from 20 percent to 33 percent.[45] During the same period, technological developments resulted in a 20 percent reduction in the weight of the average aluminum can. In 1984, 556,000 metric tons of aluminum were reclaimed from old cans. This is ten times as much as the corresponding figure in 1974. In addition the U.S. exported 245,000 metric tons of aluminum scrap in 1984, more than half of it to Japan, which sold it back to us as finished products.[46]

Some scholars have seen the evolution of the aluminum industry as a harbinger of a new epoch in American industry, when requirements for materials diminish and a greater share comes from recycled scrap.[47]

Other Metals

Scrap metal has been one of the earliest commodities in human commerce. The ability to reuse metals indefinitely by reshaping them is one of the fundamental characteristics of this class of materials.

The scrap metal business is a mature industry, with well established markets, marketing practices, specifications and sectors. Except for aluminum recycling this industry grew up without much direct influence from government policy or municipal practices. Scrap metal accounts for a large percentage of the total material used in the manufacture of new metal products by American industry. About 55 percent of the lead, 40 percent of the stainless steel, 40 percent of the gold, 26 percent of the iron and steel, 28 percent of the silver and 15 percent of the zinc in new American products originates in scrap.[48]

Much of the scrap used in manufacturing never leaves the industrial sector. Waste metal produced by the metal industry is just returned to the furnaces. Scrap that never leaves the factory is known as "home scrap" and is desirable because it is of known quality. Likewise, metal using industries return their scrap to their metal suppliers. This so called "prompt scrap" includes sheet metal from which can lids or other shapes have been punched. It also includes shavings and turnings left after metal is drilled or machined. The type of scrap of most interest to the municipal waste sector is called "obsolete scrap" and includes any discarded metal product which is destined to be shredded and remelted. Some types of obsolete scrap, such as structural steel from demolished buildings and bridges, are highly valued by metallurgists.

Most of the obsolete scrap that finds its way to America's landfills and incinerators is of less interest to the industry because of the difficulty of recovering it, and because of its unknown or unacceptable quality and character.

There is a saying in the metal business that "scrap is bought and not sold." The idea is that the market for scrap responds to demand by the manufacturers and not supply. When the national or international economy creates a demand for new metal products, metal producers will pay enough to bring scrap into the market by increasing the price they are willing to pay. On the other hand, a business with scrap metal to sell cannot create demand by lowering its prices.

Scrap prices are very sensitive to economic changes. Prosperity will pull scrap metal away from municipal landfills like a giant magnet. Recession will drive it back in. Recession will also lower the amount of waste produced, but not nearly to the same degree. A fairly steady supply of waste and a highly volatile market for scrap are the basic economic conditions that waste recyclers must contend with.

■ **Ferrous Metal:** 1973 was a great year for the "tin" can, which is really a steel can with a thin coating of tin on the inside. More than 30 billion tin cans were sold to beer and soft drink makers. Eleven years later, the number of steel soft drink and beer cans had declined to 4 billion, about 13 percent of the peak years. Between 1980 and 1984, the total tonnage of discarded steel containers, including large pails and drums, declined by 17.9 percent.[49] The current rate of 2.4 million tons of steel container discards per year is projected to decline to 1.8 million tons by the year 2000.

Less than one half of one percent of steel discards are recovered for the purpose of recycling, and the trend seems to be down. Operators of mass burn incinerators have some incentive to remove steel prior to incineration. Whether the recovered steel goes to market or to landfill depends on market conditions.

Large steel drums used to be recycled more frequently than is the case today. Chemical residues in these containers create hazardous waste regulatory and environmental problems that scrap dealers are trying to avoid.[50]

A bright spot in the steel recycling picture is the performance of so-called minimills, which produce steel products almost exclusively from scrap. In the late 1970's steel production from minimills was growing at the rate of ten percent a year. By 1983, minimill production accounted for 18 percent of all steel made in the United States. During the same period integrated steel mills in the U.S., which produce metal from ore, were experiencing economic difficulties.[51]

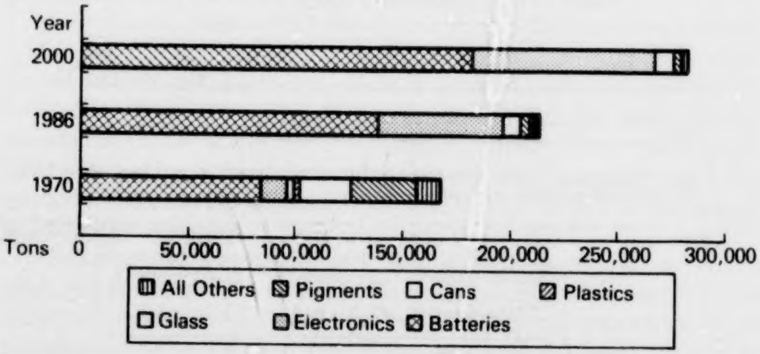
■ **Heavy Metals:** A number of metals of a certain class, known as heavy metals, tend to be toxic to living organisms in relatively low concentrations. Toxic heavy metals of this sort include mercury, cadmium, lead and arsenic[52], among others. These metals are also known as trace metals, because they are found in only parts per million in the earth's crust. (Contrast this with aluminum or iron, each of which comprises about five percent of the earth's crust.)

There is a growing body of scientific evidence that trace metals are circulating through the biosphere at unprecedented rates and that this increased circulation is a result of human activity. Refuse disposal through incineration and landfilling is an important source of cadmium, mercury, lead, vanadium, copper and zinc in the air, water and soil. "The greatly increased circulation of toxic metals through the soils, water and air and their inevitable transfer to the human food chain remains an important environmental issue which entails some unknown health risks for future generations."[53]

The phase out of lead from gasoline has brought about a rapid and dramatic reduction of lead levels in streams and rivers.[54] Solid waste has supplanted auto exhausts as the major contributor of lead to the environment.

Automobile lead-acid storage batteries are by far by the biggest source of lead in the municipal waste stream. Even though recycling rates for batteries range from 52 to 80 percent, more than 138,000 short tons of battery lead found its way to our landfills and incinerators in 1986 and the trend is up. Consumer electronics, especially television picture tubes, are also a large and growing source of lead.

Figure 6. Lead in Discards of Products in Municipal Solid Waste, 1970, 1986, and 2000.



Source: *Characterization of Products Containing Lead and Cadmium in Municipal Solid Waste in the United States*, 1970-2000 (Draft Report July 27, 1988), prepared for U.S. Environmental Protection Agency, Office of Solid Waste.

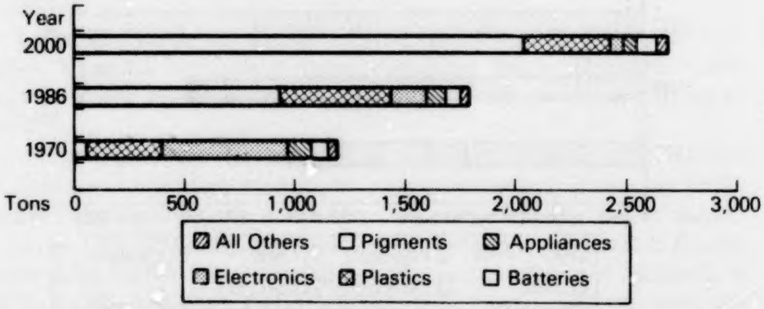
In recent years, the market for reclaimed lead has experienced a good deal of volatility. In 1979, the rate of battery lead recovery was about 90 percent. By 1985, the rate had fallen to 58 percent. This resulted in the delivery of 296,000 tons per year of batteries to municipal landfills and incinerators, which for the most part were not equipped to manage them safely.[56]

As the federal government and the states develop more restrictive hazardous waste regulations, lead recycling, which diverted more than 700,000 tons of battery lead from the waste stream in 1986,[57] is becoming more expensive and difficult. It is reasonable and prudent to anticipate that the growing costs of proper recycling will generate more illegal dumping of this common and dangerous pollutant.

Concern about toxic waste regulation has also put a crimp in the recycling of so-called white goods, such as refrigerators, stoves and other appliances. Appliances and engines built before 1980 frequently contain PCB's and other chemicals classified as toxic, which the law requires must be given special treatment. Many of the businesses that recycle white goods are now reluctant to involve themselves in hazardous waste management. Refrigerators and air conditioners also contain chemicals that pose a threat to planetary ozone. While the problem has been identified, solutions have not emerged.

Increasing quantities of cadmium are finding their way into the waste stream via nickel-cadmium rechargeable batteries. Nicad batteries are used in portable consumer products, such as rechargeable flashlights, hand vacuums, food mixers, screwdrivers and the like. While these popular and handy devices have a long working life, when the battery fails, the entire device – plastic case, battery and other parts – is tossed in the trash. There

Figure 7. Cadmium in Discards of Products in Municipal Solid Waste, 1970, 1986, and 2000.



Source: U.S. Department of Commerce, International Trade Administration, *The End-Use Markets for 13 Nonferrous Metals,* June 1986.

are no significant recycling programs for worn out rechargeable tools. Plastics are another significant source of cadmium in the solid waste stream.[58] Cadmium is used as a stabilizer for polyvinyl chloride and as a pigment in other resins. The quantity of cadmium being discarded is very small in comparison with lead. But, depending on the circumstances of their disposal, they can create health and environmental concerns.

Rubber

Americans discard rubber tires at the rate of one tire per person per year. In the 1960's about 20 percent of our used tires were retreaded and put back on the road. By 1984, the rate of retreading had dropped to 5.2 percent, and continues to fall. On the other hand, because of smaller cars and more durable tires, the tonnage of rubber discards declined by 44.8 percent from 1960 to 1984. Cyclical declines in auto sales have had a major influence on this trend.[59]

Tires are a vexing problem for waste managers. Unlike metals, vulcanized rubber cannot be melted down and recast. Moreover, old tires defy burial in landfills. They work their way up to the top of the pile.

Tire carcasses are ideal breeding grounds for mosquitos and other disease vectors. The tires hold water and shield the bugs from pesticide sprays. The Center for Disease Control has uncovered evidence that Asian tiger mosquitos, carriers of dengue fever, have entered the United States in used tires, and are spreading rapidly as the tires move in commerce. Another foreign pest, the lacrosse encephalitis mosquito, is hitch hiking its way across America in the same vehicle. Although no cases of encephalitis or dengue fever have developed in the U.S.,[60] one way to avoid a serious outbreak is to keep the tires dry. A number of states, including Illinois, Ohio and South Carolina, have recognized the danger and are developing or have already promulgated rules to insure proper storage of tires.

Many of our used tires end up in huge tire dumps. The largest such dump is in Modesto, California, where forty million tires have found a temporary resting place. More typical is the tire pile in St. Mary's County, Maryland, which holds about three million. Tire dumps can pose a significant hazard, as is illustrated by the fire at a dump in Winchester, Virginia, which started in October 1983 and burned and smoked for eight months. Federal cleanup teams spent $1.2 million in a mostly successful effort to keep the molten rubber from polluting nearby streams.

Tires have a high heat value and, when properly shredded, burn well in municipal incinerators. A number of processes have been developed which make economically valuable products from old rubber. Elastomerics, Inc. in Minneapolis, Minnesota and Oxford Energy Co. in California are two examples of innovative companies in this field.[61] However, 90 percent of used rubber is disposed rather than recovered.[62]

Plastics

Plastics are the fastest growing segment of the trash pile. In 1960, annual discards of plastic were about 0.8 billion pounds, representing about one half of one percent of the total waste stream by weight. By 1986, the figure had grown to more than 20 billion pounds, or 7.3 percent of total garbage. By the year 2000, 9.2 percent of our wastes are projected to be plastic, or 31.2 billion pounds.[63]

Since 1960, plastic production has grown 2 to 3 times as rapidly as the gross national product. Between 1987 and the year 2000, the industry is projected to expand at the annual rate of 3.9 percent.[64] Most of this phenomenal growth is reflected in the municipal solid waste stream. More than half of all discarded plastic is packaging. Plastics used in packaging have increased from 4.7 billion pounds in 1970 to 12.8 billion pounds in 1985 and may reach 22.6 billion pounds by 2000.[65]

Because of its lightness, plastic takes up a good deal more space in a landfill than its weight might suggest. A cubic yard of plastic weighs about 250 pounds. A cubic yard of mixed municipal waste weighs from 800 to 1,200 pounds.[66] Not surprisingly, the growth of plastic waste is a significant factor in the using up of landfill capacity.

Plastics are thought to be chemically stable in a landfill environment, although more research is needed in this field. One study of plastics with cadmium pigments found that landfilling did not result in a significant leaching of cadmium into the environment.[67]

A pound of plastic has almost as much heat value as a pound of residual fuel oil, and is therefore prized by incinerator operators. Controversy exists as to the air pollution emissions resulting from burning plastics, and the toxins that might settle out in the ash. Attention has thus far been directed chiefly at polyvinyl chloride. The issue is whether incinerating this resin produces dioxins and furans.[68] Much more research is needed regarding other combustion byproducts.

Burning plastic to produce electrical energy or steam recovers only about ten percent of the energy used to manufacture the plastic in the first place. On the other hand, certain types of processes for using recycled plastics to produce new plastic require an energy expenditure that is less than ten percent of that required for the manufacture of plastic from virgin material.[69] The ultimate energy balance must be determined by the particular circumstances of particular applications.

Litter is one of the special problems of plastics. Paper biodegrades and iron rusts in the open environment. But plastics, like diamonds, are forever. In recent years, the problem of plastics in the ocean has gotten a good deal of attention.[70] Among the responses to this problem is a call for degradable plastics. Types of plastic that degrade in the open have been developed, based on materials that break down under exposure to ultraviolet wavelengths, and addition to polymers of starches which are eaten by enzymes in the environment. However, most uses of plastics, particularly in food packaging, are based on plastic's ability to resist degradation. Some states have taken a more direct approach by banning such common litter items as the plastic rings which hold together six packs of beer and soda. Congress also passed the Plastic Pollution Research and Control Act (PL. 100-220), which among other things bans the discharge of plastic waste in the ocean by the end of 1988.

Plastic recycling became a common practice at the factory in the 1970's, when soaring energy prices drove up the price of feedstocks and made scrap material recovery an economic necessity.[71] However, recycling of discarded consumer products is still a rarity.

Less than one percent of post-consumer plastic is recycled. Virtually all such plastic comes from bottles made from polyethylene perephthalate (PET) and high density polyethylene (HDPE). PET containers are used most widely for large soft drink bottles, and HDPE is used in milk and detergent containers.

Many obstacles must be overcome before plastics recycling takes its rightful place in the array of solid waste management techniques. To begin with, there are many kinds of plastics which look alike and cannot easily be separated. Many products are composed of layers of different resins laminated together, or affixed rigidly. Most uses of recycled plastic require a pure product. However, mixed plastic wastes can be made into a wood like construction material which can be cut, sawed and nailed to make fencing, boardwalks, docks, outdoor furniture, road signs and other items that are able to resist weathering.

A second obstacle is the fact that a scrap market infrastructure has not developed for plastics other than PET and HDPE. States with mandatory soft drink deposit laws provide most of the PET currently recycled. In other states, however, adequate collection and separation systems have not yet developed. This is not to say that the potential is not there. For example, the PVC pipe industry could easily absorb the 560 to 570 million pounds of PVC currently being used in packaging applications. However, no mechanisms exist for identifying, collecting and transporting the packaging waste to the pipe makers. This is in contrast to other recyclables, where the infrastructure exists, but the market potential is just not large enough.

A third problem with plastic recycling is that the low density of plastic makes transportation particularly expensive.

Finally, consumers are not sufficiently aware of the recycling potential of plastic and do not get involved with recycling in this field to the same degree as they do in connection with paper, aluminum and glass recycling. Most people are unaware, for example, that scrap PET or HDPE plastic sells for about six cents a pounds, which is a good deal more than paper (1.5 cents) and a good deal less than aluminum (70 cents).

Two factors provide reason to anticipate significant improvements in the rate of plastic recycling. First, state governments are imposing ever stricter requirements on waste plastic. Second, the industry has made a major commitment to developing a plastics recycling system.[72]

California, for example, requires beverage distributors to pay the state one cent per beverage container sold. The pennies are returned to consumers when they return the containers. Container manufacturers are then assessed a processing fee on each container sold if the scrap value does not equal the state-calculated cost of redemption and processing. By December 1989, those container types that are not at a 65 percent recycling rate will be assessed a refund value of two cents per container, and that figure will increase to 3 cents per bottle in December 1992 if the 65 percent rate is still not achieved.

The plastics industry has one of the best records in American business for research and development. R & D has been a major factor in the remarkable growth of plastics markets. There is reason to hope that the research abilities of the industry may be enlisted in the service of solid waste management. The industry has responded to the call for recycling by establishing a number of industry wide associations and projects designed to research and publicize recycling. Even more significant, individual companies have been making capital investments in recycling systems.

Summary

The materials of the waste stream are as diverse and abundant as the American economy. The discussion above sums up the trends, unique qualities and problems of some of the most plentiful and troublesome components. Any analysis of the individual components of solid waste is after the fact and somewhat artificial. For the most part, these materials flow into our waste systems as a well mixed mass. Separating the aluminum, paper, plastic and ink in a simple pudding container can be technically and economically daunting.

From a municipal waste manager's point of view, solid waste is a single commodity, a mass to be moved away, buried and burned. But the effects of solid wastes on the environment and the options for management can only be understood by a sorting out of the individual components.

The aluminum industry has shown what can be accomplished when manufacturers concern themselves with their products as they cycle through the environment. The plastics industry is at least talking about mounting a similar effort and may be pushed to move faster by aggressive state legislation. Glass and paper recycling is progressing due chiefly to local government initiatives. The situation with regard to other commodities, especially batteries, tires and white goods seems to be deteriorating.

Technological Options

Source Reduction

Source reduction has been defined as the design, manufacture and use of products so as to reduce the quantity and toxicity of waste produced when the products reach the end of their useful lives. Two examples of source reduction are: the decrease in the use of mercury in dry cell batteries by 65 percent since 1984; and the 20 percent reduction in weight of aluminum beverage cans. Products that last longer, such as radial tires, slow the rate of waste production. Most of the positive changes in this direction have been in response to economic stimuli having little direct relationship with waste management. Although there are many exceptions, the direction of consumer products has been towards increases in waste rather than decreases.

Many examples of waste reduction can be found in the industrial sector. Cutting waste has always been a responsibility of business managers. As modern regulations imposed new costs on waste disposal, especially toxic wastes and as raw material costs and costs of handling and processing materials increased, the rate of waste reduction accelerated.[73]

In the past, some states have enacted outright bans of certain products perceived to be creating special problems as a regulatory means of source reduction. An example would be the ban on phosphate detergents, designed to prevent water pollution, enacted by many of the coastal and Great Lakes states. At the federal level, some consumer and environmental organizations are petitioning the Food and Drug Administration to withhold approval of polyvinyl chloride as a beverage container material on the grounds that PVC produces toxic gases when incinerated, and that it would replace easy to recycle aluminum cans.[74]

Consumer preference can be a force for source reduction, but there are very few examples of organized educational or advertising programs to persuade consumers to choose certain products over others because they have less impact on waste management.

Reuse and Recycle

Community recycling programs are deemed successful if the cost of the program is less than the sum of (a)the revenues from sales of recycled materials plus (b)the avoided costs of landfilling or incineration.[75] By this measure, there are hundreds of successful recycling programs in the U.S. Wilton, New Hampshire, a small town of 8,500 people recycles about 44 percent of its wastes by weight, earns revenues of about $27,000 and avoids $50,000 to $100,000 a year in landfill costs over and above the expenses of the recycling program. Montclair, New Jersey reduces its waste load by 23 percent by its mandatory recycling program. While Montclair has been recycling since 1971, its program really picked up steam in July, 1987, when the cost of landfilling quadrupled over night. About a fifth of Portland, Oregon's 450,000 service population participates in a comprehensive recycling program that diverts about 24 percent of the city's solid waste.[76]

Some characteristics of successful community recycling programs are: programs are custom designed by local people to suit the needs of the particular locale; good (though not necessarily expensive) public education programs find efficient ways of reaching target audiences and utilizing volunteer citizen leaders; trash containers are designed for the convenience of the consumer; collection times are frequent and well chosen. With regard to this last point, one city found that its program of picking up and composting grass clippings worked best when pickup took place on Mondays, the day after most people mow their lawns, than on Fridays. Common sense considerations of this sort make the critical difference.

The business of recycling has been sharing in the success of the municipal sector. In 1970, in the wake of the first Earth Day, thousands of recycling programs sprang up all over the country. By the mid 1970's, when the general economy had experienced a down turn, more than half of them fell by the wayside. Today the recycling business is coming back stronger than ever, this time on a sounder financial and entrepreneurial basis.[77]

The majority of community recycling programs rely on consumer separation at the home. Such "free" labor is one element of recycling's cost competiveness. However, consumer separation is not the only alternative. A number of communities sort the garbage at processing facilities. Some of these processes are labor intensive, relying on hand sorting of materials that have been partially sorted at curbside. Others are high tech, employing magnets, special conveyor belts, flotation devices and the like. Perhaps the best example of a multi-technology recycling facility is the 130,000 square foot, $9.5 million Marin Resource Recovery Center, in Marin County, California. This privately owned facility reclaims about 25 percent of the solid waste produced by 85,000 residents in 17 jurisdictions in Marin County, a suburb of San Francisco. The facility employs an equal mix of human labor and machines to process the waste, and a small herd of sixty pigs to "process" the discards from area restaurants, supermarkets and food companies. Says founder and president, Joseph J. Gabarino, "Recycling has always been good for the environment. Now we're learning how to make it pay."[78]

An especially profitable type of recycling is remanufacturing, a process for rebuilding durable products such as large appliances and automobiles by replacing worn out parts. By 1985, more than 600 companies had entered this growing industry, about double the number in business in 1981.[79]

Composting

Composting has been practiced since the beginning of history. It is mentioned in the Bible and evidence of the practice can be found in archaeological digs of civilizations from the year 6000 B.C. The "dung heap" of the King James translation of the Bible is often as not a compost pile in the original Greek or Hebrew. Composting is a process for producing humus, a kind of soil conditioner, from the decomposition of organic material. It is a natural process which can be seen at work, for example, in the litter on the floors of forests. It is nature's way of rebuilding soil. In general the decomposition is effected by thermophilic or heat loving bacteria in the presence of oxygen and moisture. Most home gardeners have some knowledge of compost and how to make it. One savant has suggested that the great American gardeners are distinguished more for the quality of their composts than the beauty of their flower arrangements.[78]

Large scale composting as a way of managing solid waste first came into common use in northern Europe, and many of the leading technologies still bear a made in Europe label.[79] In United States, composting on a large scale has been used chiefly as a means of managing sewage sludge, agricultural manures and yard wastes. Finished compost is generally free of pathogens.[80] The odor is not offensive and the material is homogenous in texture and color. Moreover, the product is useful and can often be sold or utilized for landscaping, gardening, landfill cover and agriculture. Its primary beneficial properties are that it holds water well and is especially useful in times of flood and drought and as a way of minimizing erosion; it causes the nutrients bound up in the soil to be released to plants; it facilitates the uptake of micronutrients; and it improves the tilth or workability of the soil. Most composts add a small amount of nutrients directly to the soil.

A number of European cities have used composting to manage solid waste generally. Salzburg, Austria has been operating a solid waste composter for many years. The key to success is to remove as many metals, toxic chemicals and other inorganic materials as possible. The remaining organic fraction of the waste stream is still very high and includes food and yard waste, paper and natural fibers. Portland, Oregon and Sumter County, Florida are among the many American communities starting up large solid waste composting systems.

A significant problem with large scale composting is that some of the processes tend to give off unpleasant odors. These can usually be avoided by careful management of the piles, various air filtration and negative air pressure cleaning systems and by enclosing the facility. Nonetheless, enough incidents occur to create neighborhood concerns about this technology. A second problem is that composts tend to hold onto the heavy metals found in the raw materials being composted. This makes land application of some composts, especially those made from sewage sludge from industrial areas, problematic. In this regard, there is tremendous variability between one compost product and another.[83] Finally, it is often said that compost is difficult to market and that cities risk being "stuck" with it. Years of experience tend to show that those communities who hire skilled marketing professionals mostly move their product out.[84]

Landfilling

The sanitary landfill is one of the great public health innovations of the twentieth century. For most of this century, in most American cities, garbage was disposed of in open dumps. These were breeding grounds for rats and vermin of all sorts. Open dumps frequently caught fire, creating noxious fumes and smoke and endangering trespassers and workers.

In sanitary landfills, garbage is compacted and covered with soil on a daily basis. The daily cover, compaction and other management practices prevent fires, discourage pests and generally keep the operation more sanitary and less offensive. The United States Environmental Protection Agency has promulgated criteria defining the characteristics of sanitary landfills in 1979. Facilities that fail to meet these criteria are considered open dumps and are deemed to be operating illegally. EPA is now in the process of upgrading the criteria.

Landfills are located throughout the United States. Five states, containing or in close proximity to some of our largest municipalities (Texas, California, New York, Maine and Wisconsin) account for 40 percent of America's municipal solid waste landfills. More than half of the nation's landfills are small, handling less than 17.5 tons per day. Seventeen percent handle between 17.6 and 50 tons per day. And 32 percent handle more than 50 tons. The largest 157 landfills, or 2.6 percent of the total, handle 40 percent of all municipal landfill waste. EPA estimates that the cost of operating a large (1,500 TPD) landfill properly is $6 per ton. The comparable cost for a small facility (10 TPD) is $55 per ton.

Table 4. Size distribution of municipal landfills.

AVERAGE SIZE LANDFILL (TPD)	ACTUAL SIZE RANGE (TPD)	NUMBER	PERCENT	PERCENT OF TOTAL WASTE HANDLED
10	1–17.5	3,093	51.3	1.6
25	17.6–50	1,028	17.0	3.8
75	51–125	791	13.1	8.6
175	126–275	442	7.3	10.9
375	276–563	334	5.5	16.3
750	564–1,125	189	3.1	18.6
1,500	>1,125	157	2.6	40.2
Total		6,034	100.0	100.0

Detail may not add to totals because of rounding.

TPD = tons per day.

Source: EPA Municipal Solid Waste Landfill Survey.

Municipal governments own 81 percent of landfills; private companies own 15 percent; and states and the federal government own the remainder.

Major problems with sanitary landfills are siting of new ones, generation of methane gas, pollution of ground and surface waters by leachate and generation of odors. Keeping inappropriate materials out of landfills is a recurrent problem. Closing a landfill in a safe and secure manner represents a large future cost.

Methane, a kind of natural gas, is generated by the anaerobic decomposition of organic materials in the landfill. Methane can be so plentiful, that about 100 landfills collect it for commercial energy use. Among the largest such systems is a gas recovery system operated by Brooklyn Union Gas at one of New York City's giant landfills. The system produces enough to meet the energy needs of 10,000 homes. For the most part, however, methane is a dangerous nuisance. Methane explosions have tossed debris more than 1000 feet off site, and caused injury and death in a few cases. Methane is especially dangerous when it "migrates" through the soil and accumulates in the basements of nearby buildings, in wells and other confined places. Sad experience has led most states to ban all construction on closed landfills, which continue to generate gas for years. Newly proposed federal Environmental Protection Agency rules require monitoring for methane and ban explosive concentrations of the dangerous gas at the edge of the landfill.[85]

EPA evaluated case studies (albeit a non-representative universe) of 163 municipal solid waste landfills and found that 146 facilities were contaminating groundwater; 73 were contaminating surface waters. The most common contaminants were iron, chloride, manganese, trichloroethylene, benzene and toluene. At several sites, drinking water sources were contaminated. The pollution "plume" at three of the sites extended to the base of the aquifer, or groundwater formation, to a depth of 70 feet in two cases, and 300 feet in one case. The water pollution plume from one site migrated a half mile down gradient; at another site the plume extended a mile and a half.[86]

The pathway for pollution of both ground and surface water is the "leachate," liquid which passes through the landfill. The rain water that runs off the landfill can also carry contaminants off site. Most states have adopted and the federal EPA has proposed rules requiring groundwater monitoring, leachate collection and treatment and run-off controls. In addition, new or currently operating sections of landfills must be lined with plastic or clay liners to block migration of contaminated water.

Odor problems continue to be reported from landfills. About 875 of the nation's 5200 operating municipal landfills have been cited for air pollution violations.

Thousands of closed landfills are under investigation for potential threats to health and the environment. To minimize such problems for the future, new federal and state rules require that new landfills have a plan for closure at the time of licensing, and that landfill owners provide assurance that money will be available to cap off, monitor, and maintain the landfill for as long as needed to prevent water pollution or gas explosions.

Municipal facilities that comply with EPA's new rules covering landfills are likely to be much more costly and complex than older fills. They will also be much safer to human health and the environment.

No system of solid waste management can avoid use of landfills. The most thoroughgoing recycling system will always leave a residue of unusable material that must find its way to the landfill. Incinerators leave a residual ash behind that must be put somewhere. Moreover, for all their difficulties, in many areas landfills still represent the most economical solution to many particular solid waste problems. A complicating factor in this economic calculation is that most owners of landfills have no clear idea of the true costs of operation. Many costs are overlooked, especially future costs, and many are hidden in the various public accounts that subsidize municipal waste management.

The most visible and immediate problem with landfills is that they are closing down (often in response to stricter regulation) and filling up much faster than new ones are being sited and developed.

Combustion

Ten to fifteen percent of American municipal solid waste is burned up in combustion facilities. Prior to 1976, most incinerators served only one purpose — to reduce the weight and volume of waste by converting it to smoke and ash. After 1976, energy recovery, usually electric generation by steam or steam heat, became an additional purpose. The drive to generate energy from waste was sparked by the energy crisis of the 1970's. Spot shortages and rapidly rising energy prices caused the Congress to create a number of tax and other incentives which fostered significant investments in so-called resource recovery facilities. The 1981 tax reduction, especially provisions creating tax credits for capital investments, allowing accelerated depreciation deductions, and permitting issuance of tax free industrial development bonds gave waste combustion a powerful boost until these tax preferences were eliminated or scaled back by the tax reform of 1986.

There are now in operation in the U.S. about 134 municipal trash burning facilities. They fall into three categories: mass burn, modular and refuse derived fuel (RDF). A mass burn plant consumes the entire waste stream, except for such large items as refrigerators, without preprocessing. They range in size from 50 tons per day to 1000 tons per day, although most of the newer ones tend to the larger sizes. A modern mass burn plant is equipped with a waterwall furnace for energy recovery. Some facilities consist of two or more combustion trains for purposes of backup and to accommodate waste streams of 3000 tons per day or more.

Modular combusters are small (5 to 100 tons per day), two chamber, factory built facilities. They take the trash without preprocessing.

RDF plants are designed to incinerate only the burnable portion of the waste stream. The incoming solid waste is processed through a series of shredders, screens and density classifiers, which separate out metals, glass and other non-burnable constituents. These materials are either recycled or sent to landfills. The burnable residue, usually paper and plastic is sometimes formed into pellets and burned in dedicated industrial boilers or co-fired along with coal or oil in utility furnaces.

The economics of waste combustion, especially mass burn, are volatile. In 1987, more combustion capacity was cancelled than was planned. The tax reform act of 1986 removed some of the tax advantages of energy recovery. Controversies about siting, regional agreements and pollution control have slowed or stopped many plants. The costs of air pollution control are rising as standards become stricter. Uncertainty about how to manage the ash produced by mass burn plants could alter the cost accounting of plants in decisive ways.

Many combustion facilities are owned and operated by private companies under contract with municipal governments. A typical contract provision is known as "put-or-pay." The idea is that the municipalities guarantee a certain amount of trash, for which they are charged a tipping fee based on tonnage. If less trash is delivered the municipality is obliged to pay anyway. Another important legal consideration is the relationship between the mass burn facility and the consumer of the energy produced. Public utilities are obliged by federal law to take the energy and to pay a price for it based on the avoidable cost of building a new generator. This price is often greater than the market value of energy. In practice there is often a good deal of dispute between the electric utility and the resource recovery company about the quantity of energy accepted into the grid and the price paid. These disputes may be avoided by negotiating a long term energy contract with a local industry or government agency.

Trash combustion generates a variety of air pollutants, including particulates, metals and toxic substances. These are for the most part controllable through a use of electrostatic precipitators, fabric filters known as baghouses[87] and lime scrubbers. A few facilities are equipped with all three. But the high capital and operating cost of these devices has caused many in the industry to challenge requirements they regard as excessively strict. Continuing uncertainty as to air pollution standards is an impediment to the growth of combustion technology.

Strict air pollution controls produce another even more difficult environmental problem — disposal of ash. Combustion facilities yield two kinds of ash: bottom ash and fly ash. For facilities equipped with scrubbers, the fly ash combines with chemicals added to the flue gas, usually alkaline reagents such

Table 5. Municipal waste combustion facilities in the United States.

	1988 START-UP OR IN OPERATION		UNDER CONSTRUCTION		FINAL PLANNING	
TYPE OF FACILITY	NUMBER OF FACILITIES	CAPACITY (TPD)	NUMBER OF FACILITIES	CAPACITY (TPD)	NUMBER OF FACILITIES	CAPACITY (TPD)
Waste combustion only[1]	38	13,608	0	—	0	—
Mass burn[2]	42	34,657	17	21,804	3	3,850
RDF[2,3]	21	23,100	5	5,822	3	3,897
Modular[2]	33	4,436	0	—	3	780
Total	134	75,801	22	27,626	9	8,527

[1] U.S. EPA, Muncipal Waste Combustion Study: Report to Congress, June 1987. Older, waste-reduction only facilities.

[2] U.S. Conference of Mayors, NRRA, *City Currents*, October 1987. Waste-to-energy facilities.

[3] Refuse-derived fuel.

as lime. The combination of ash and lime can equal 10 percent of the waste stream by weight.[88]

Mass burn plants reduce the weight of trash by 75 percent. The remainder must be disposed of, usually in a landfill. Most of the ash is bottom ash or slag. About ten percent of the residue is flyash, the stuff that would pour from the chimney if it were not captured by precipitators and baghouses.

All told, incinerators in the U.S. produce about three million tons per year of ash. This figure is likely to double or triple as new units come on line and as air pollution control standards are tightened. The ash contains many of the chemicals found in the waste, plus a few combinations generated by the combustion. In general, the fly ash is much more hazardous, in terms of toxic metals and dangerous organic chemicals such as dioxins and furans, than the bottom ash.[89] However, the bottom ash may also contain significant quantities of lead and other hazardous constituents.[90] The current practice is to mix the two types of ash before landfilling so as to lower the concentration of hazardous materials.

The behavior of the hazardous constituents of incinerator ash in landfills is a matter of intense debate and uncertainty. A Swedish study, for example, concludes that the dioxins that are present in fly ash are so firmly bonded to the ash particles that they will not leach out in water. However, contact with solvents that may also be present in landfills could cause the dioxin to leach into ground water.[91]

Solid waste combustion is hedged in by a series of as yet unanswered questions about ash. What is to be done with the ash? Should it be handled as a hazardous waste, requiring special processing and high cost landfilling, or should it be placed in normal municipal fills? Is it appropriate to mix bottom ash and fly ash, or is this a case of impermissible pollution dilution? Can the toxins in the ash be reduced or locked in so they do no injury? Is it feasible from an economic and environmental point of view to create monofills, or dedicated landfills for ash alone? What level of government should make the final decisions as to ash regulation?[92]

Summary

The techniques for managing solid waste include source reduction, recycling, composting, landfilling and combustion, often combined with energy recovery. The predominant mode of management continues to be landfilling. Old fills are closing down rapidly and new ones are being sited and opened very slowly and with great difficulty and expense due to tighter standards. This has made expansion of other modes a matter of some urgency. Combustion technology is beset by controversy about environmental impacts and costs. The true potential of recycling is also matter of considerable dispute; although there is general agreement that this mode of management can be expanded rapidly. Composting can provide a convenient means of removing a significant fraction of the waste stream from landfills and incinerators. However, this technology must still overcome its reputation for foul odors and create consumer confidence in product quality. Source reduction is the least developed of all the available options.

Institutional Resources

Local Government

The real action in solid waste management is at the local level. Here one finds examples of the most exciting and forward looking recycling programs, the best run landfills and energy recovery facilities (as well as some substandard landfills and incinerators). The major issues on the local level are planning and siting, regionalization, financing, regulatory compliance and technology choice.

A proposal to site a landfill or incinerator inevitably evokes the same reaction from those who live nearby: we don't want it! The uniformity of reaction sometimes leads local officials to feel that all sites are more or less the same. In fact, of course, proper site selection requires careful technical evaluation, to systematically account for geology, water bodies, wetlands and flood plains, transportation, screening and aesthetic considerations, other public or private facilities in the area, physical constraints on construction due to soils and slopes and similar factors of this sort. An increasingly important consideration is the community's willingness to accept the facility where science and economics dictate. Those local officials who manage to combine technical considerations with public approbation in the selection of solid waste sites are arguably the most able and under appreciated leaders that our democracy produces.

Capital budgeting is another challenge facing local decision makers, especially in connection with landfills and the ash disposal facilities of incinerators. Life cycle accounting that considers all the costs from planning and siting through to postclosure care and possible cleanup is still a relatively new planning tool as applied to solid waste facilities. Trash combustion facilities may require frequent overhauls and maintenance, factors which are sometimes omitted from local calculations. On the revenue side, local governments need to decide what combination of tipping fees and taxes is optimal to fund their waste operations. As the potential for recycling grows, they need to calculate revenues from sales of recovered items or energy, which while significant may be very difficult to predict accurately.

Economies of scale are a critical factor in landfills. The very small ones can be ten times more expensive on a per ton basis than the large ones. Incinerators also evidence economies of scale, but to a much more limited degree, and only up to a point. Similarly, recycling programs can benefit from a pooling of regional facilities. Regionalization, while often talked about, is difficult to put into practice. Among the obstacles to be overcome are the reluctance of citizens to accept trash from other jurisdictions, the lack of regional planning institutions which offer equal treatment to jurisdictions of different sizes, and uncertainties as to liability and cost sharing issues. The large number of very small solid waste systems, and the difficulty they face of operating in a safe and economical manner makes it imperative for local governments to confront the daunting problems of regionalization.

State and federal regulation of solid waste management is accelerating. This development grows out of the lack of regulation in the past, the new found notoriety of solid waste, and the many genuine scientific uncertainties in this field. Moreover, the waste stream is changing rapidly, as the economy evolves. The net result is that local governments are required to make forty year investments in facilities governed by rules that are almost certainly going to change in the next five years. Local governments need to build resiliency and variety into their waste management systems.

Private Sector

The private sector is a big player in the solid waste industry. Private companies haul garbage, own and operate landfills, run recycling facilities and build and operate trash combustors and compost and recycling facilities, often under contract with local governments. Advantages of private service providers may include: more professional staff and technical capabilities; a sharing of risk; availability of capital finance; faster turn around time for construction of new facilities; and more flexible labor agreements. Many private providers deal directly with businesses and residents. A growing number provide services under contract with local governments. Such contracts tend to be extremely complex, and require knowledgeable negotiators on both sides.[93]

Non-profit organizations have had notable success in the solid waste business, especially in the area of recycling, where they have tended to be pioneers, proving the feasibility of approaches that the profit sector was reluctant to try.

Organized crime has also been involved with trash collection for many years. An unanswered question is whether the explosion of new regulations and laws will drive out criminals. Some experts fear that the rising cost of waste disposal may draw more criminal organizations into the waste industry.[94] On the other hand, the plethora of environmental laws makes it easier for aggressive prosecutors with adequate technical assistance to prove criminal violations.

The potential of the private sector to manage municipal solid waste is being tested in many communities that have contracted out traditionally government provided services. Clearly the field has prompted some exciting ventures. The next few years should bring out even more private economic activity.[95]

State Governments

Federal law puts state governments at the forefront of planning and regulating. Solid waste management is at or near the top of many state legislators' priority lists.[96]

Capacity limitations and siting controversies in solid waste management have invited regulatory intervention by a number of state governments. States such as New Jersey, California, Florida, Vermont, Oregon, Minnesota and others have established comprehensive environmental regulation of landfills, developed planning and siting mechanisms, set recycling goals and established state procurement rules favoring recycled materials, banned or restricted certain types of packaging, established rules governing disposal of medical wastes and taken numerous other steps designed to gain control of the solid waste issue before it gets further out of hand. Some states have even begun to develop regulations governing incinerator ash disposal. Many of these initiatives were taken in response to anticipated federal rules; others were prompted by the lack of federal rules.

Critical issues for state governments are the extent to which they involve themselves in siting decisions; whether they provide financial aid and technical assistance; how well they use their own administrative structures to promote recycling; the extent to which they interfere with national commerce; how they relate to changing federal rules; and how they administer a system of regulation and enforcement, especially in connection with local governments and those who provide essential services to local governments.

Labor Force

Sanitation workers are the foundation of waste management in the United States – 60,000 men and women who lift the cans, remove the trash and operate landfills, incinerators and recycling centers. Median income of sanitation workers is a little less than $15,000 a year.[97] About eleven out of every hundred will experience a serious accident this year, mostly back and muscle injuries. This makes their trade more dangerous than coal mining and forestry. The majority of sanitation workers, who are employed by government, are not covered by the Occupational Health and Safety Act. The labor union that organizes the largest number of them is still at work on its first pamphlet or film on worker safety.[98]

Training of sanitation workers is haphazard. Yet these workers are increasingly being required to operate expensive, complex and dangerous machinery. At the landfill or incinerator gate, they are charged with the task of keeping out toxic, infectious, or explosive materials. To its credit, the American Society of Mechanical Engineers is involved in an ongoing effort to develop a model incinerator training and certification program for operators.

On the other hand, a number of community facilities have successfully trained and employed mentally handicapped people to help process the wastes coming in, to separate the different colored bottles, for example. Many of the sheltered workshops for people with physical and mental handicaps which are run by such organizations as Goodwill Industries, are in essence recycling centers, where discarded clothing and furniture is made usable and marketable.

Critical issues for the labor force are: the adequacy and availability of training; ways of improving worker safety; type of people required for different jobs; the rights of workers in connection with shifts of functions between public and private service providers; the role of workers in recycling and hazardous waste exclusion; development and operation of operator certification programs; and opportunities for advancement.

Federal Role

In September of 1988, the U.S. Environmental Protection Agency issued a draft agenda for action which set out a series of national goals and objectives relating to solid waste management. The goals are as follows:

- The United States must find a safe and permanent way to eliminate the gap between waste generation and available capacity in landfills, incinerators and in secondary materials markets.
- Source reduction and then recycling are the preferred options for closing the gap and reducing the amount and toxicity of waste that must be landfilled or incinerated.
- All waste management practices should be made safer.

The objectives are:

1. Increase the waste planning and management information (both technical and educational) available to States, local communities, waste handlers, citizens and industry, and increase data collection for research and development.
2. Increase effective planning by waste handlers, local communities and States.
3. Increase source reduction activities by the manufacturing industry, government and citizens.
4. Increase recycling by government and by individual and corporate citizens.

5. Improve the safety of municipal solid waste combustion in order to protect human health and the environment.
6. Increase the safety of landfills in order to protect human health and the environment.

At about the same time, the Agency issued a set of proposed regulations establishing minimal standards for operating landfills. The Agency is also planning to issue rules regarding air pollution and ash disposal practices for trash combustors. EPA has also begun to encourage the establishment of procurement programs aimed at getting government agencies to buy recycled goods. If and when this procurement policy is implemented throughout the government, it promises to advance the cause of recycling a long way. The difficult administrative task is to convince other agencies of government to incorporate the recycling ethic into their daily operations.

Perhaps the most difficult challenge to the federal government is to carry out its objectives in ways that build upon and do not impede the progress made at the state and local level and in the private sector.

Future Directions

The term "integrated waste management" has become a sort of watchword in the waste management industry. EPA defines integrated waste management as "the complementary use of a variety of waste management practices to safely and effectively handle the municipal solid waste stream with the least adverse impact on human health and the environment." The emphasis here is on variety, the use of all or some of the techniques discussed earlier in this chapter. At a deeper level, the idea of integration suggests coordination. For example, the community that waits until it has signed binding contracts for a mass burn plant of a certain size and capability before it begins planning a recycling program has not integrated or coordinated its system.

Similarly, the waste management system should be designed to deal with the future, not just the present. The new EPA rules on landfills are designed, as they must be, for facilities that receive today's mix of waste. The problem is that the waste stream is likely to undergo significant changes as recycle and reuse practices and consumer products evolve. Integrating the future into waste management is one of the most difficult challenges presented by this field.

Waste management in America is also burdened by its past. Thousands of old dumping grounds dot the landscape. Some of these are in areas that were once on the outskirts of big cities, but which are now in the midst of the suburban and rural residential developments, posing potential hazards that are still being assessed. The federal government will share responsibility for only a handful of these sites through its Superfund program. For the most part, old dumps are the responsibility of state and local governments, or the landowners.

At present it seems that solid waste management in many, although not all, parts of America is nearly overcome with the burden of current daily waste loads. But as in so many other areas of public policy, America is fortunate in its institutions. Our complex web of local, state and federal governance and our rich mixture of public and private institutions are well suited to sorting out a problem with so many layers of complexity.

Those communities facing serious landfill shortages are being forced by circumstances to develop innovative waste management practices and even a new social ethic to bring about safe, economical waste management. Businesses that are alert to these changes can expect to benefit from them. Federal government agencies should cooperate with local businesses and other private and public institutions, not supplant them, in what will become a nationwide effort to discover and test effective technologies and innovative arrangements to deal with municipal solid waste.

To this end, the President's fiscal year 1990 budget message included the following principles to guide federal agencies in executing the Administration's policies to encourage pollution prevention and waste minimization:

- Reducing waste at the source is the best way to deal with the problem;
- The President believes that EPA's current national goal of 25 percent waste reduction, through recycling and reducing wastes at the source, can be exceeded;
- Waste minimization must start at home and in the local communities. Citizens must be willing to reduce their garbage and separate their wastes for recycling purposes, or else be willing to accept nearby incinerators or landfills;
- Effective waste reduction techniques both in industry and in local communities should be shared.[97]

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Urban Air Quality

2

The analysis of urban air quality status and trends presented in this chapter focuses solely on ozone (O_3) pollution. Of the six "criteria" pollutants identified in the Clean Air Act, ozone pollution is the most persistent problem that commands national attention. Previous reports of the Council on Environmental Quality (CEQ) have pointed out that the federal standards for sulfur dioxide, particulates, lead and nitrogen dioxide have been achieved almost everywhere in the nation. The Los Angeles Basin is the most notable exception with respect to nitrogen dioxide. There are still approximately 50 urban areas in nonattainment for carbon monoxide (CO), which has highly localized impacts. Nationally a general long term improvement in ambient CO is clear.[1]

The establishment of the PM_{10} ambient standard in lieu of the TSP standard for particulates has triggered a new round of ambient air quality impact analyses to determine if some State Implementation Plans will have to be revised because of PM_{10} nonattainment. Some 16 urban areas, each having populations of over one half million people, and over 40 smaller areas, currently fall into this category. Development of PM_{10} monitoring networks is nearing completion and a complete assessment of the nation's PM_{10} air quality will be forthcoming when all sites have collected the requisite 3 years' data.

The Clean Air Act Amendments of 1977 set the deadline of December 31, 1987, for attainment of the National Ambient Air Quality Standard (NAAQS) for ozone. This deadline has passed and many areas of the country have not yet attained the federal standard, but the Clean Air Act (CAA) has not been amended to reflect a revised policy to deal with the issue at hand.

Health Effects and Observed Ozone Air Quality

The current National Ambient Air Quality Standard for ozone is 0.12 parts per million (ppm), not to be exceeded more than one day per year on the average. It is measured as the highest hourly average for the day (the daily peak one-hour concentration). On smoggy days the peak ozone concentrations occur in the afternoons. The provisions of the Clean Air Act require that the Administrator of the U.S. Environmental Protection Agency (EPA) set an ambient standard that is protective of human health *with an adequate margin of safety*. The current standard is based on a review of the previous standard undertaken in 1978 when it was stated in terms of photochemical oxidants as 0.08 ppm. (Photochemical oxidants are about 90 percent ozone.) At that time, the lowest concentration associated with any observed physiological effect was 0.15 ppm of ozone, which was determined from stress testing of healthy individuals exposed to this concentration during heavy exercise. EPA set the new standard for ozone at 0.12 ppm to provide an adequate margin of safety. The basis for the NAAQS for ozone is subject to review by the EPA Administrator every five years.

There are new studies which have shown reversible physiological lung function changes and symptomatic effects below 0.15 ppm which may suggest that the current margin of safety is not so clear cut. An extensive discussion of this new data shows that there is a widespread difference of opinion within the scientific community as to the relationship between clinically observed lung function changes and respiratory symptomatic effects versus potential health effects in normal populations.[2] This EPA staff paper states that there may or may not be a margin of safety at the current standard of 0.12 ppm, depending upon how the definition of a health effect is resolved. If a new determination is made that the standard requires revision, then a new regulatory strategy based on a revised standard would have to be developed. On the other hand, most modifications of the standard would not require fundamental changes in currently planned control strategies but, rather, might require additional measures to attain a more stringent standard.

The proper translation of clinical exposure results to real world exposures in terms of health risk is often overlooked. Actual ozone exposures above the NAAQS in most urban areas today are clustered very close to the 0.12 ppm level. The exception to this observation occurs only at monitoring sites where a large number of exceedances are observed. EPA's analysis of 1985 through 1987 nationwide monitoring data[3] showed that of 224 urban areas where O_3 is monitored, 101 showed one or more expected exceedances of the 0.12 ppm standard. Very few of these urban areas had more than 10 exceedances of the standard, i.e., about 15 areas. Some areas which are designated as separate

Metropolitan Statistical Areas (MSAs) have common borders and hence are in the same air shed. Seventy five percent of the urban areas experienced only one day above 0.14 ppm, while only five percent had one day above 0.18 ppm. As explained below, except for the 1988 drought effects, very few extreme exposures occur, with the exception of the Los Angeles Basin, Houston, and the downwind area of New York City.

Revising the Ambient Ozone Standard

A related issue is whether or not the current ozone ambient standard is stringent enough. The current primary and secondary ozone standards have been under review for the past several years by EPA's Clean Air Science Advisory Committee (CASAC). Although there has been some concern raised about the adequacy of the 0.12 ppm primary health standard, the board has not made any recommendation to the EPA Administrator concerning whether to change the standard. The committee was split on the issue of the adequacy of the primary standard and is expected to provide written recommendations to EPA in 1989. There have also been questions raised about the use of a 1-hour averaging time, because longer exposures above the standard seem to be important. CASAC has suggested than an 8-hour 0.10 ppm standard be considered. However, based on some comparative analysis, this optional form of the standard appears to be statistically equivalent to the current 0.12 ppm standard in most cities. In a comparative study, EPA found that these two possible forms of the standard were equivalent in 90 percent of the cases studied.[4]

It has been recognized for some time that there are ozone effects on crops and vegetation at levels below 0.12 ppm. The Clean Air Act contains provisions for the establishment of "secondary standards," which are protective of non-health related, or welfare, effects, such as damage to crops, vegetation, materials, etc. At the present time, the secondary ozone standard is the same as the primary standard. An EPA staff review of all of the available data has concluded that a range of 0.06 to 0.12 ppm be considered by the Administrator if the secondary standard is changed. EPA will have to develop regulatory guidelines for the revision of SIPs if and when the secondary standard is revised.

The basic framework of the Clean Air Act involves a systems approach to air quality management for the nation. Once an environmental goal such as a NAAQS has been established, itself requiring an arduous scientific peer review process, then technological and administrative solutions are developed and implemented to meet that goal. The State Implementation Plan (SIP) process accomplishes this transition. The CAA provisions for setting mobile and stationary source emission standards must be compatible with the air quality management strategies of the individual SIPs. Otherwise control for control sake is a meandering strategy with no finite goal, which can lead to costly and unwarranted regulation. If a new ozone standard is suggested by the epidemiological and clinical evidence, then the due process established by the statute and the EPA's implementing regulations must be followed.

Use of the Second-highest Concentration Data

Many state and local air pollution control agencies have historically used the second highest measured ozone concentration as the indicator of the attainment/nonattainment status and trends. If all of the daily maximum ozone values which are measured during the "smog season" (i.e., May to September for most cities) are aggregated by concentration and frequency, a skewed distribution is observed. Figure 1 illustrates this concept for three years of observations at three sites in the Northeast. These sites are typical of the most highly impacted areas in the nation, other than L.A. and Houston. The Fairfield County site is directly downwind of New York City. Fairfield County consistently shows the highest impacts in the northeastern region of the U. S. The three years of 1983/1984/1985 were used because this sequence came very close to representing a normal three year period, as opposed to looking at the more recent three year period which was abnormally hot.

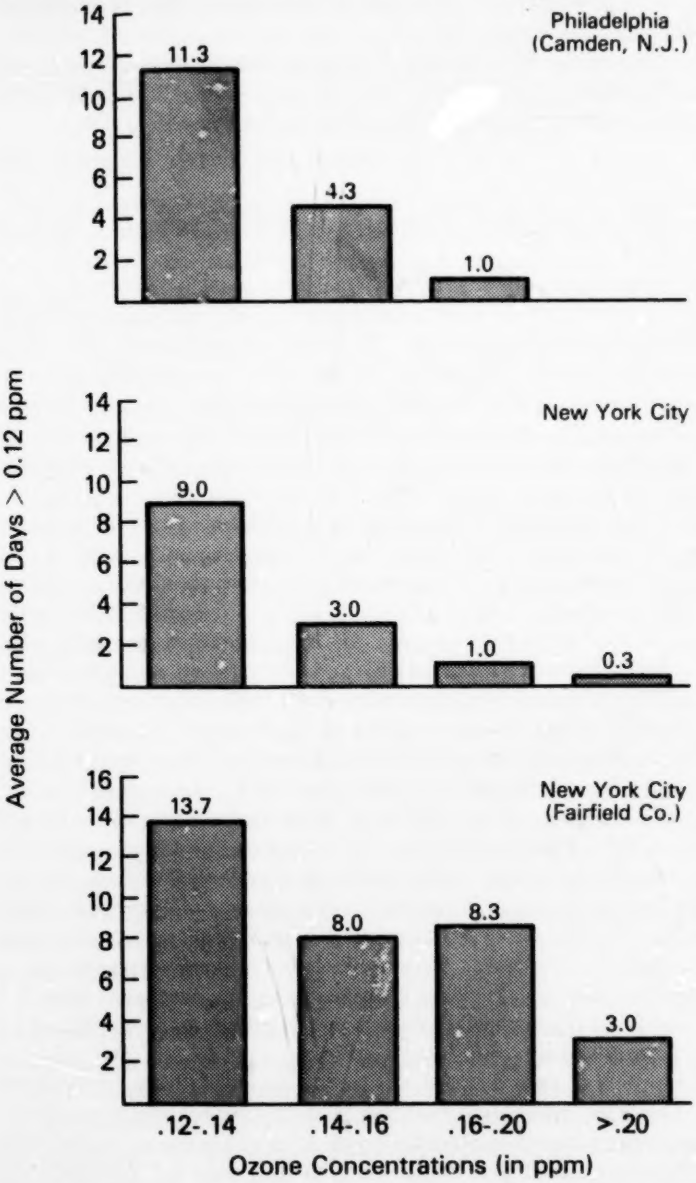
These data show that the frequency of high ozone observations above the 0.12 ppm standard diminishes rapidly with increasing concentration. (The effect of the high temperatures experienced in 1987 and 1988 on maximum ozone concentrations are discussed in the section on Conditions and Trends.) The highest observed values in the "tail" of the distribution reflect ozone levels that oc[illegible] when all of the factors conducive to ozone formation are present, i.e., abnormally high temperature, very calm wind conditions, and a low atmosphere mixing layer above the urban area. It is quite likely based on the ensuing analysis that when a region is declared in attainment, the one allowed exceedance day could have a peak concentration well above the standard, because of such a rare meteorological event.

1988 Drought Year

Currently reported ozone air quality conditions in many urban areas were influenced by highly unusual meteorological conditions associated with the 1988 drought. The 1988 drought which affected most of the nation brought about ozone impacts generally higher than observed in 1987, both from a frequency of violations and a concentrations perspective. The data reviewed in the following analysis, however, show the general improving trend that has been achieved over the past decade.

Although there is concern about the increasing levels of carbon dioxide (CO_2) in the atmosphere and the potential for global warming, i.e., the

Figure 1. Distribution of Maximum Concentration Days, 3-year Average of 3 Typical High Impact Sites, 1983/1984/1985.



"greenhouse effect," the observed 1988 drought cannot be associated with this phenomenon, even if it is occurring. The greenhouse theory relates to the gradual warming of the atmosphere over a long period of time, rather than triggering large swings in year-to-year temperature profiles as discussed in this ozone analysis. Further, there is no observed evidence that the warming trend is taking place. For example, all of Europe was abnormally cold in 1988, unlike what was experienced in the United States. Researchers[5] have pointed out that the dust bowl years of the 1930s were much hotter than 1988.

Conditions and Trends for Selected Cities

The nationwide trends of ozone levels were determined by analysis of data for 23 of the most affected cities across the nation.[6] All geographical regions of the continental U.S. are represented. There are some additional urban areas within some of the regions represented which have ozone levels higher than the worst case in other regions. For example, San Diego has a greater ozone problem than Miami. The status and trends for the most highly impacted urban area (or areas) within a region appear to be a good indicator for all areas within that region.

Although there are other smaller cities and downwind rural areas of some of these 23 cities which also reflect current nonattainment, none of these areas shows impacts (rates of exceedance of the ozone standard) comparable to the data used for the cities studied. All available site monitoring data within each urban area were used in this analysis. Sites downwind of each city which have been recognized by EPA and state and local agencies as the most highly impacted by the urban ozone plume were also included where applicable.

A typical area that is representative of this situation is a portion of Connecticut downwind of New York City, including cities as far away as Hartford. In this case, data from Fairfield County, Connecticut (adjacent to New York City) was included in CEQ's attainment status analysis, to account for such situations. Fairfield County data was not included in the trends analysis because of the extensive data base available for New York City alone. Fairfield County is the most highly impacted out of state area affected by the smog plume from New York City. Alternatively, the ozone levels in the upwind area, such as Newark, New Jersey, were not included in the analysis because the measured impacts are lower in comparison to the downwind area. It is axiomatic that if the downwind site achieves compliance, the upwind, or less impacted, area will also come into compliance.

The period of time used for this trends analysis is from 1979 through 1988.[7] This is the most appropriate time frame for two reasons. First, the current regulatory strategy in place for ozone is based for the most part on the 1982 State Implementation Plans, which in turn used the 1979/1980/1981 period as the years for establishing air quality and emissions inventory baselines. From these data, the projected control levels on volatile organic compounds (VOCs) needed to meet the 1987 attainment deadline were determined. Second, there was a change in the ozone instrument calibration methods which affected the comparability of the pre-1979 to post-1979 data in many areas of the country. Some cities, such as St. Louis, however, had monitoring systems that were not affected by such calibration changes.

The Temperature Question

CEQ has previously emphasized the importance of understanding the underlying influence of meteorology on the trends in ozone air quality.[8] The statistical form of the ozone standard is designed to provide a framework for dealing with meteorological events. This chapter sets forth a technique which adjusts observed data for temperature.

Most major cities have experienced abnormally hot years over the past three years. The basic premise of the statistical form of the national standard is that the 0.12 ppm ozone standard shall not have an *expected* exceedance rate of more than once per calendar year. The "expected" terminology is very important in analyzing observed data to determine if a particular urban area is in attainment or not. In order to determine the annual expected exceedance rate it must be determined if the observed data is representative of the long term average (that is, the "expected") meteorological situation. This clearly implies that meteorology could play an important role when interpreting data.

EPA has established a three year time interval for determining the attainment/nonattainment status of any given urban area which in part deals with meteorological influences. Thus, an area could have an exceedance profile of 0, 0 and 3 exceedances for the years 1986, 1987 and 1988 and be in legal attainment. A dilemma arises when the 3-year sequence under review in a given area is abnormally hot *or cold* relative to the long term (or "expected") average. The 3-year sequence using 1986/1987/1988 measured data illustrates the dilemma when one or more years are abnormally ***above average***. The dilemma is also illustrated by posing a paradoxical question: "What would be the interpretation of the 1987 and 1988 data if the city by city temperature profile had been abnormally *below average*?" A way to analyze the data is to develop an analytical scheme which adjusts the data to represent a normal 3-year period for each city.

CEQ and other agencies have developed methodologies for normalizing observed O_3 data.[9] One straightforward method focuses on using temperature data. For example, the annual frequency of days above 90°F is a good indicator of how many days per year are conducive to ozone formation. There are several factors that are essential to ozone formation in urban areas, e.g., temperature, wind speed, atmospheric mixing height, wind direction, etc. A more detailed analysis could include these variables as well. However, in this analysis the temperature factor alone is a surrogate for most of these variables on smoggy days.

Generally, it should not matter what the site specific threshold temperature for ozone formation is; the year with more days above 90°F will also have a proportionately larger number of days above, say, 85°F. The use of 90°F is based on the ready availability of these data in computerized form. All weather stations in the U.S. maintain monthly summaries of the frequency of days above 90°F.

The methodological concept for conducting trend analysis which compensates for year to year temperature variations is straightforward. The method used herein is not meant to represent the only or the ultimate methodology. This approach assumes that the more days above 90°F per year, the greater the likelihood of exceeding the ozone standard, assuming that emissions are held constant. If no emissions reductions take place, the ratio of the exceedances to hot days (of the "hits to opportunities") would remain about the same over time. However, if emissions reductions bring about lower daily peak concentrations of ozone, the "hits" or exceedances should decline. The indicator of the ozone trend is, therefore, the quotient of exceedances divided by the surrogate for the number of days conducive to ozone formation, i.e., the number of days a year over 90°F. This analysis uses the total number of exceedances annually for two or more sites within a metropolitan area, rather than for a single site, in order to smooth out the possible effect of wind direction during smoggy days. However, the attainment/nonattainment status analysis examines site specific data.

Historical Trends in Ozone and Temperature

In addition to examining the trend in exceedances of the 0.12 ppm ozone NAAQS, the trend in exceedances of the 90°F "conducive day" indicator was tracked simultaneously. Detailed analysis was conducted to compare the year to year temperature profiles for each city against the historical 20-plus year record of temperature trends. This historical record was used to determine what the expected (or normal) temperature year is for each city.

Figures 2 through 24 showthe trends in ozone and temperature for the 23 cities studied. The temperature profile in terms of days in excess of 90°F are compared to the historical average in each city. The use of the average or geometric mean was determined on a case by case basis using standard statistical techniques to determine whether the historical data was normally distributed (bell shaped) or log normally distributed (skewed). This data can be used to normalize each year's ozone data and the 1986/1987/1988 composite data for determining the expected (or normalized) standard exceedance rates for each city. The graphs further show the pattern of ozone exceedances

Figure 2. Ozone and Temperature Trends for Atlanta, GA.

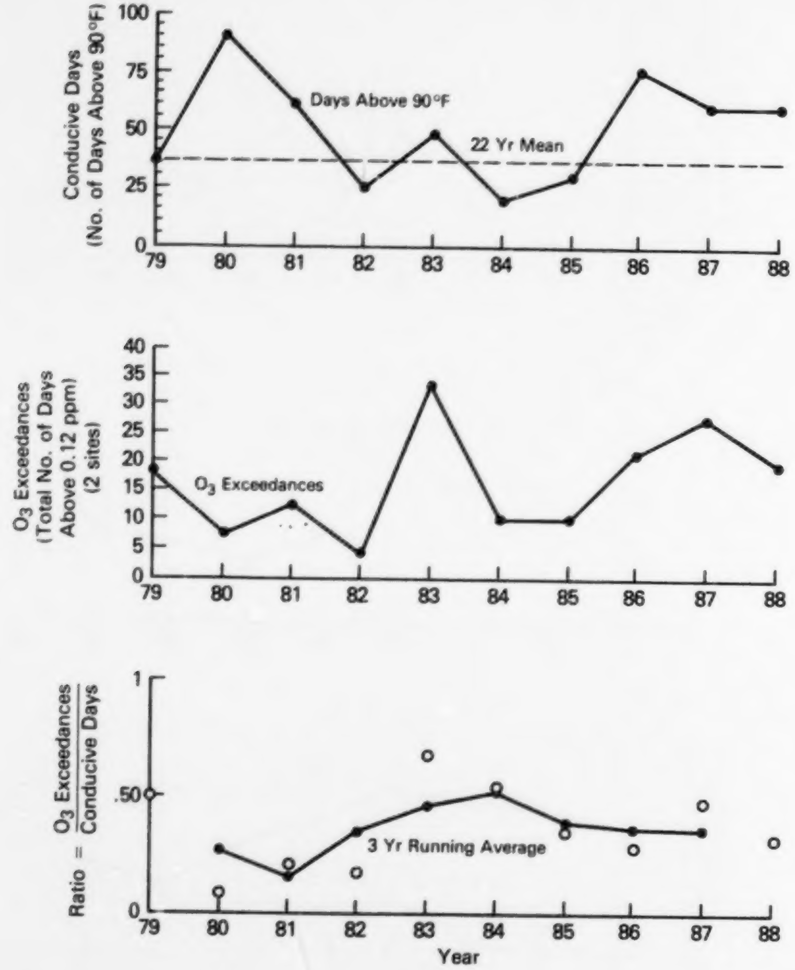


Figure 3. Ozone and Temperature Trends for Baltimore, MD.

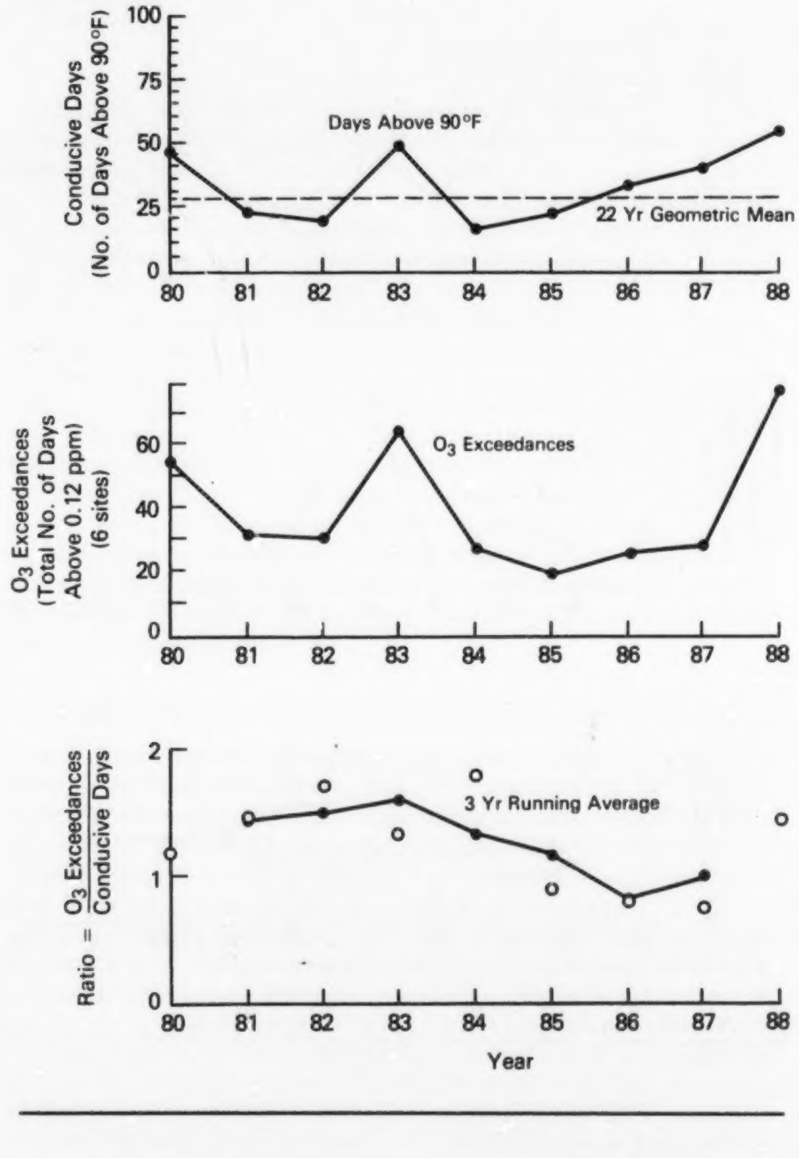


Figure 4. Ozone and Temperature Trends for Boston, MA.

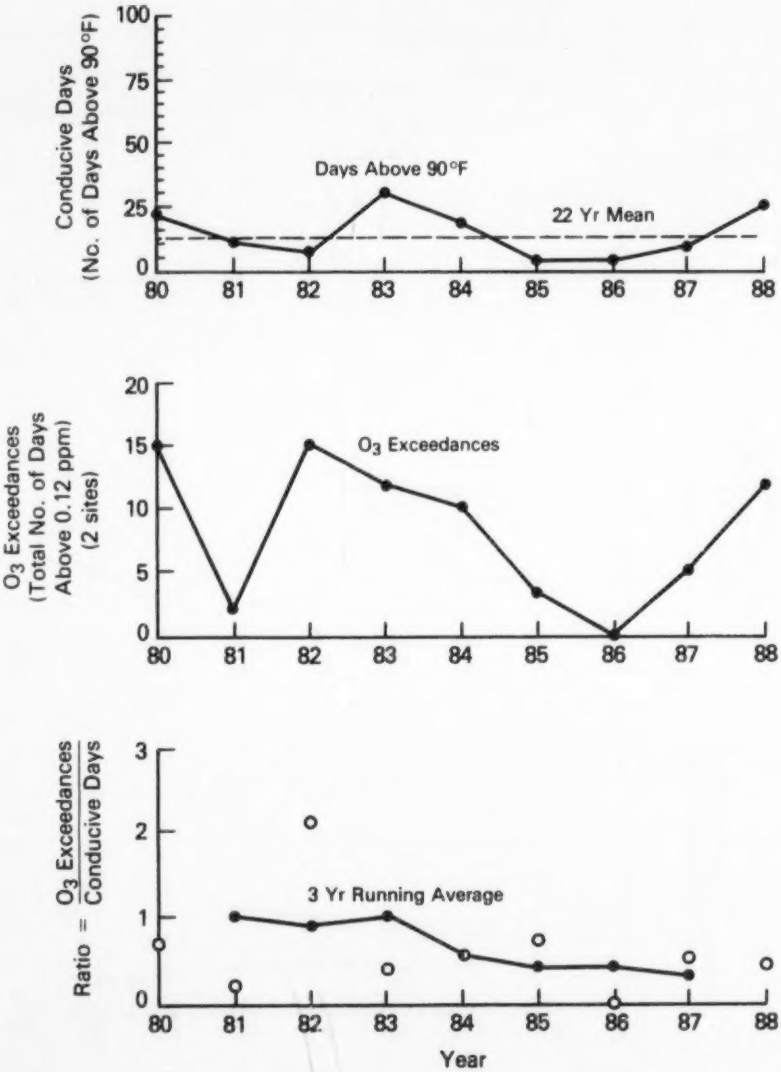


Figure 5. Ozone and Temperature Trends for Baton Rouge, LA.

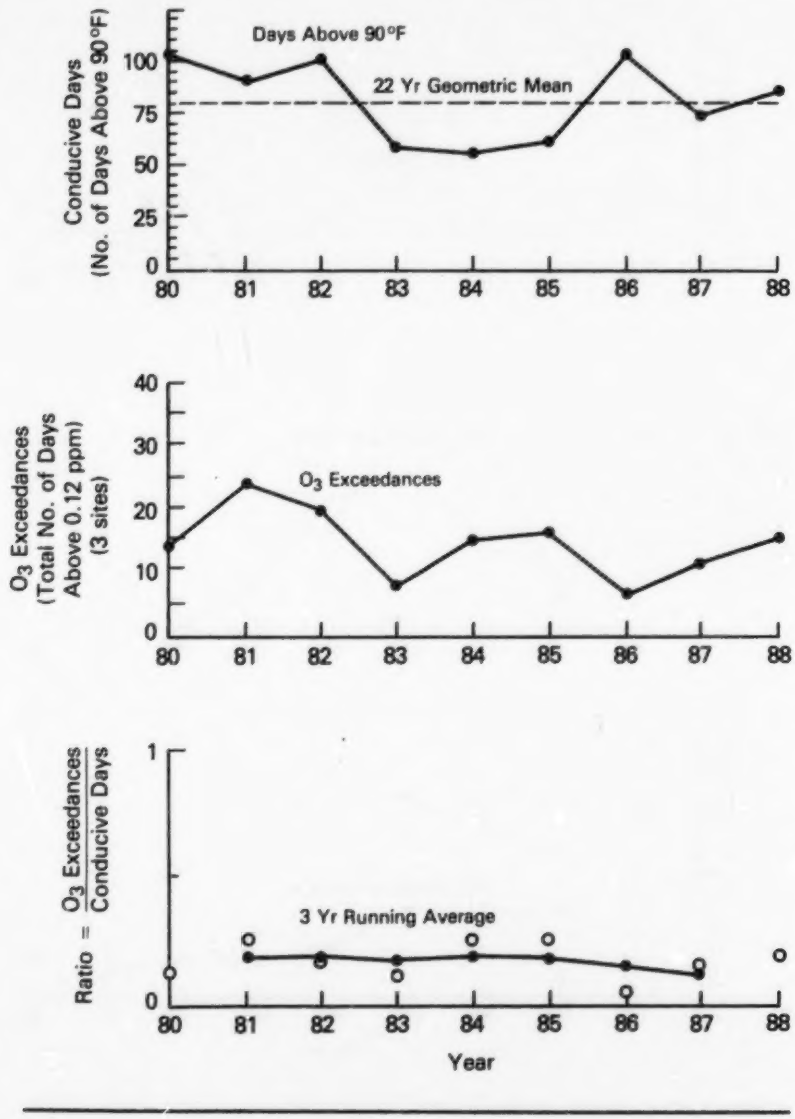


Figure 6. Ozone and Temperature Trends for Chicago, IL.

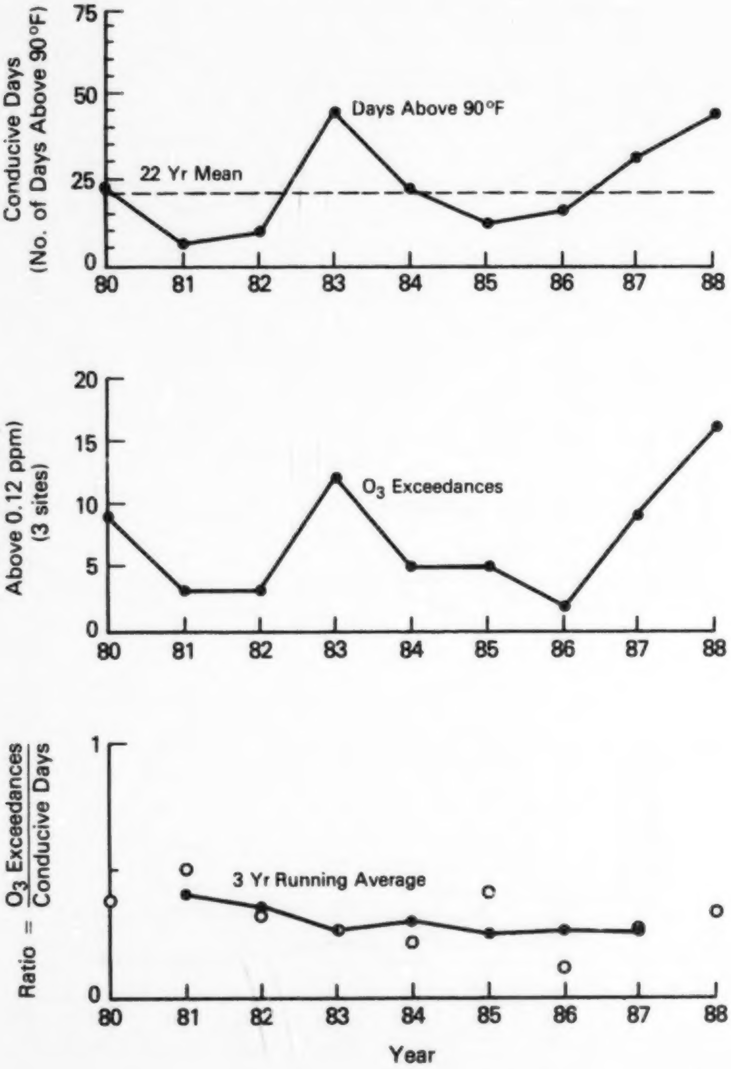


Figure 7. Ozone and Temperature Trends for Cincinnati, OH.

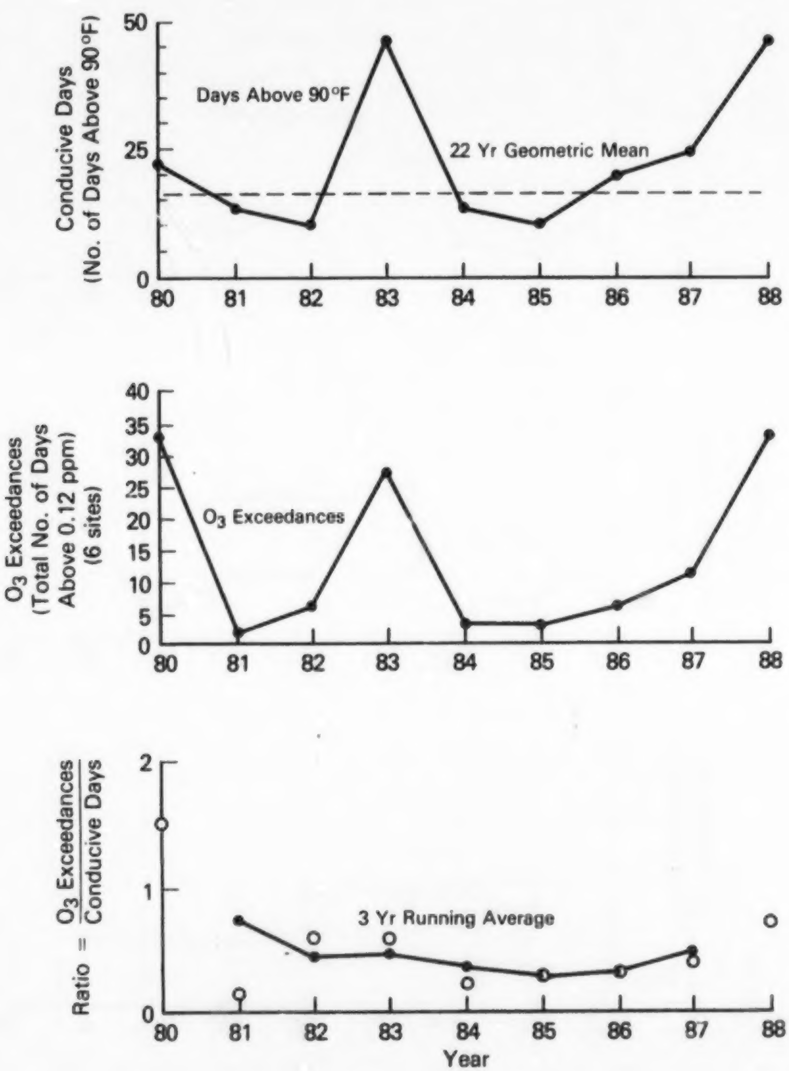


Figure 8. Ozone and Temperature Trends for Dallas, TX.

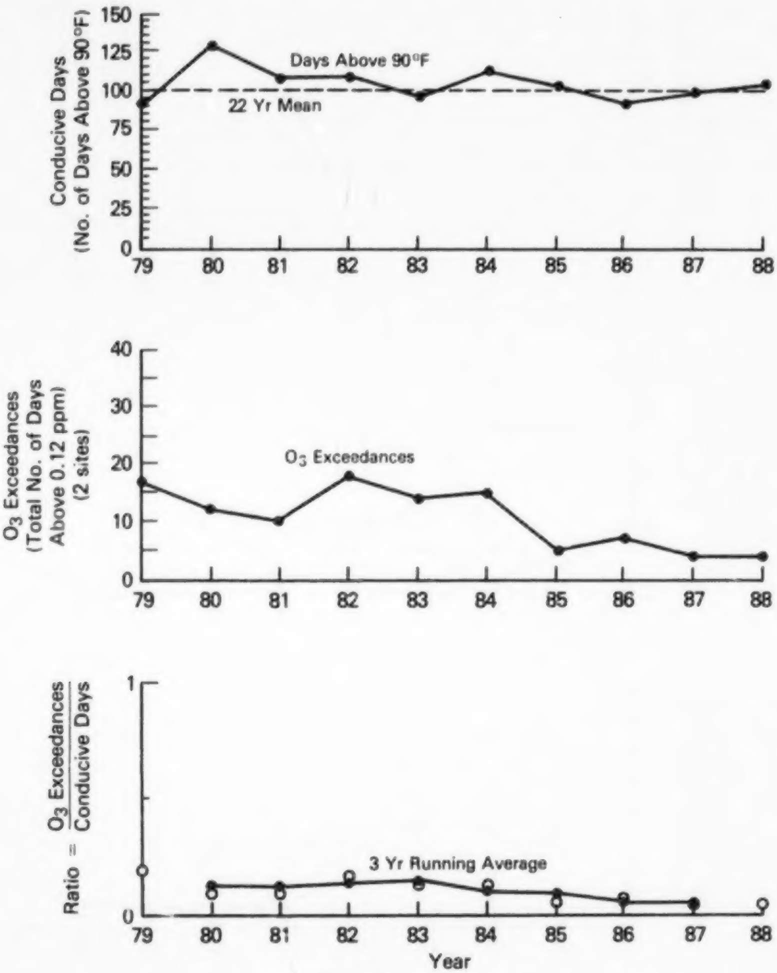


Figure 9. Ozone and Temperature Trends for Dayton, OH.

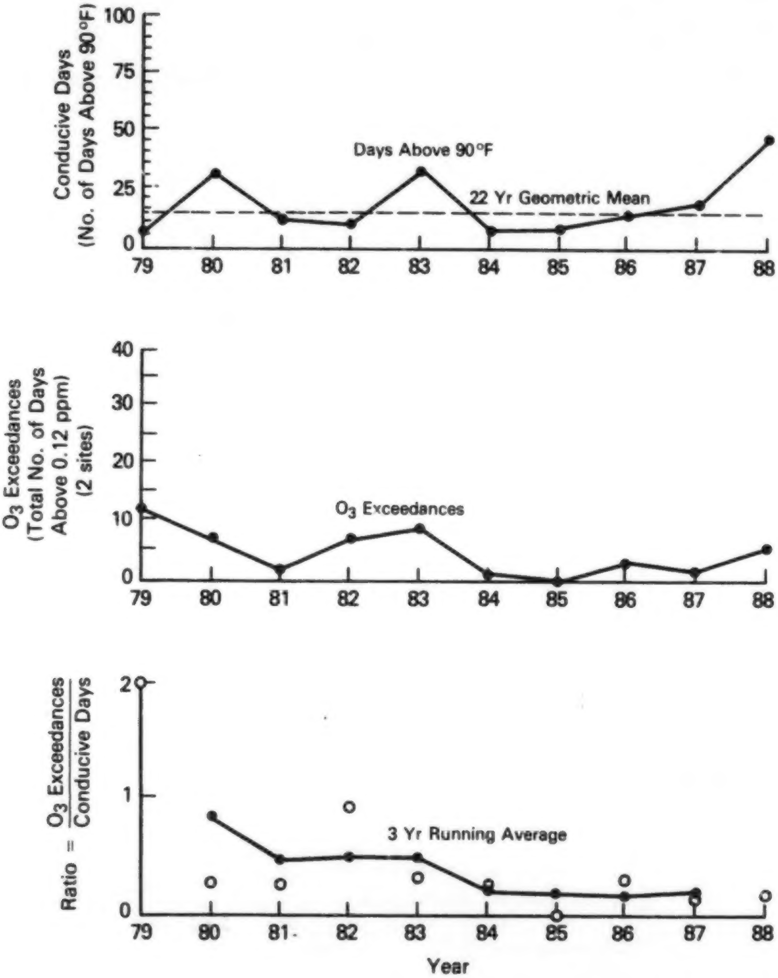


Figure 10. Ozone and Temperature Trends for Denver, CO.

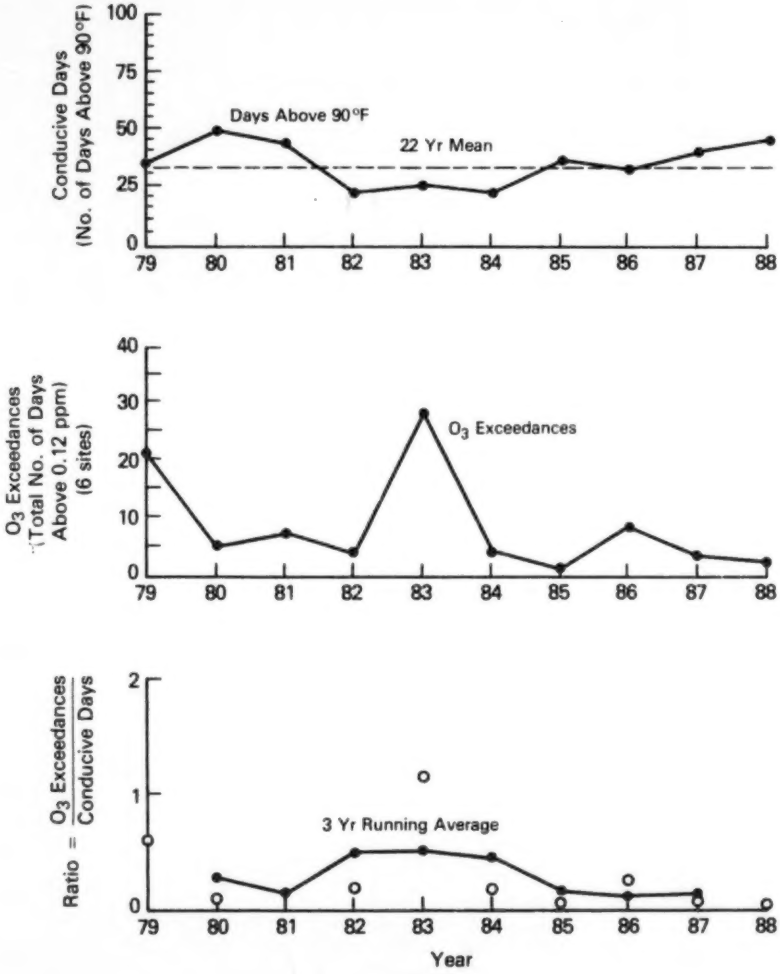


Figure 11. Ozone and Temperature Trends for Detroit, MI.

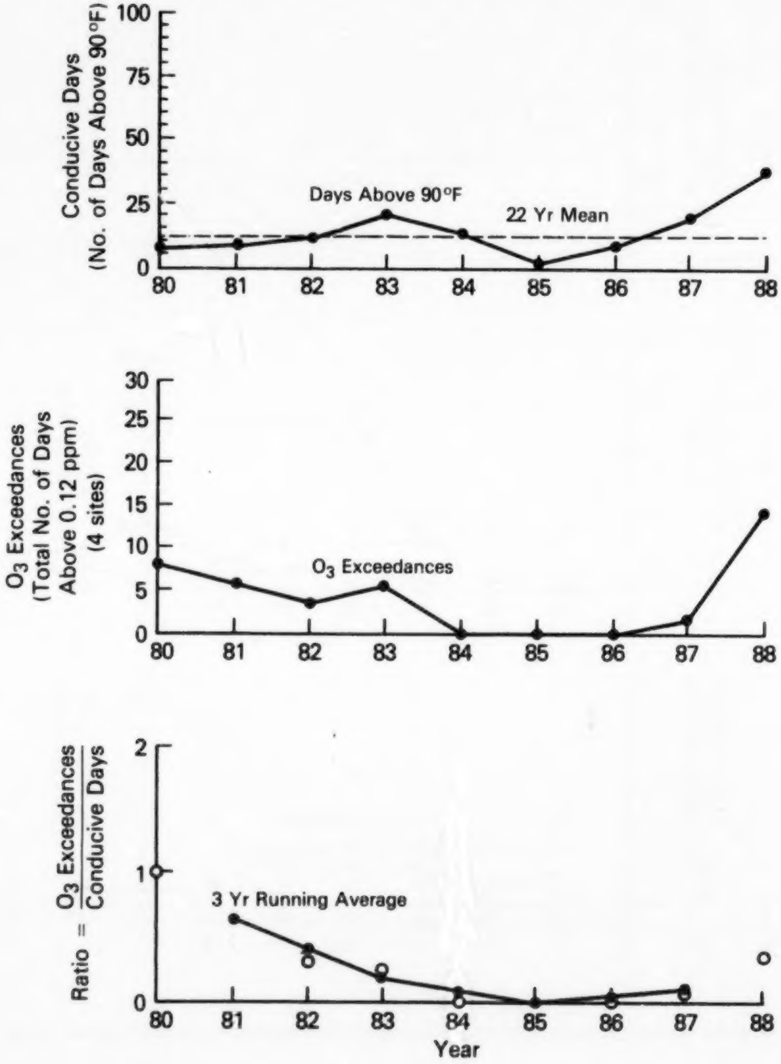


Figure 12. Ozone and Temperature Trends for Houston, TX.

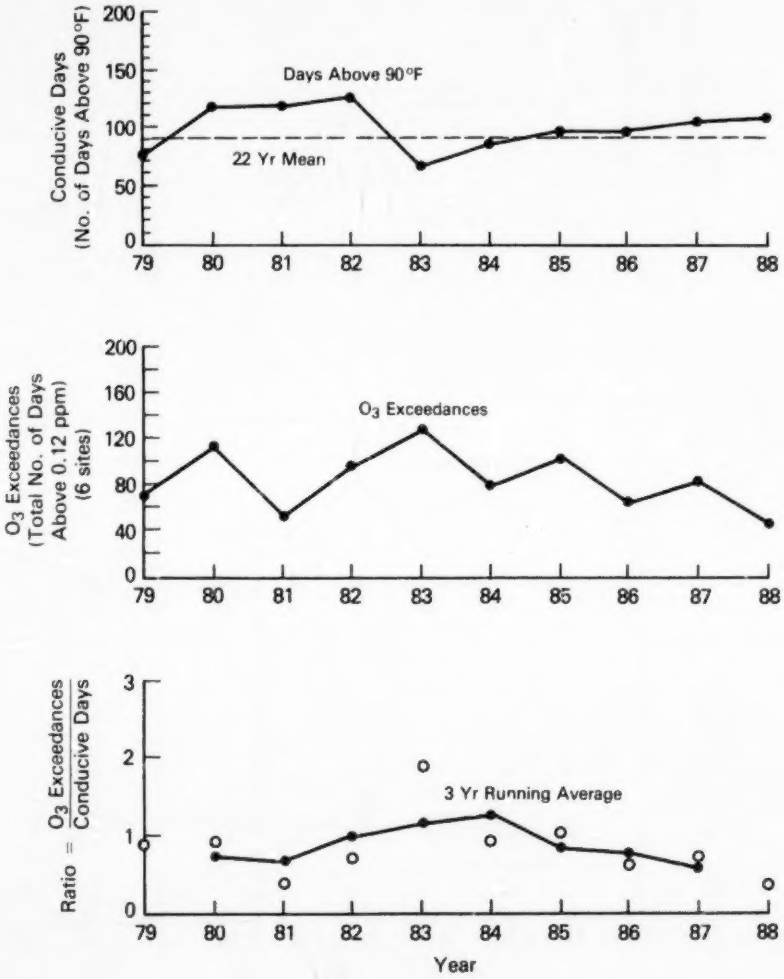


Figure 13. Ozone and Temperature Trends for Louisville, KY.

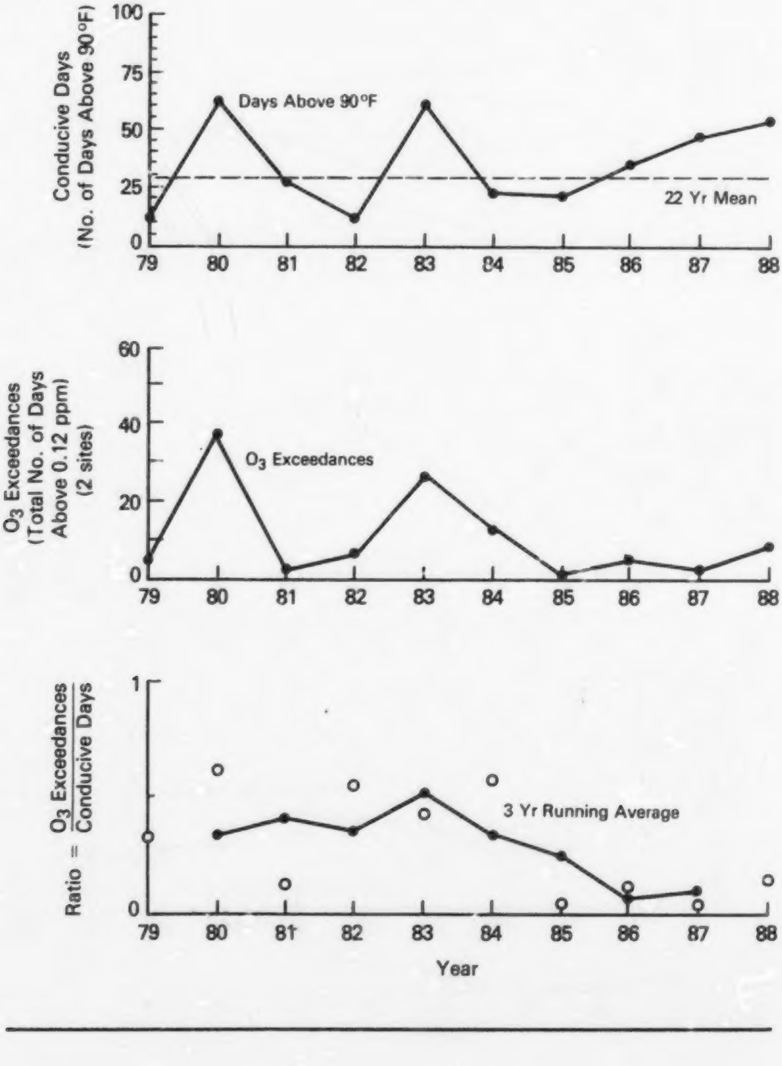


Figure 14. Ozone and Temperature Trends for Los Angeles, CA.

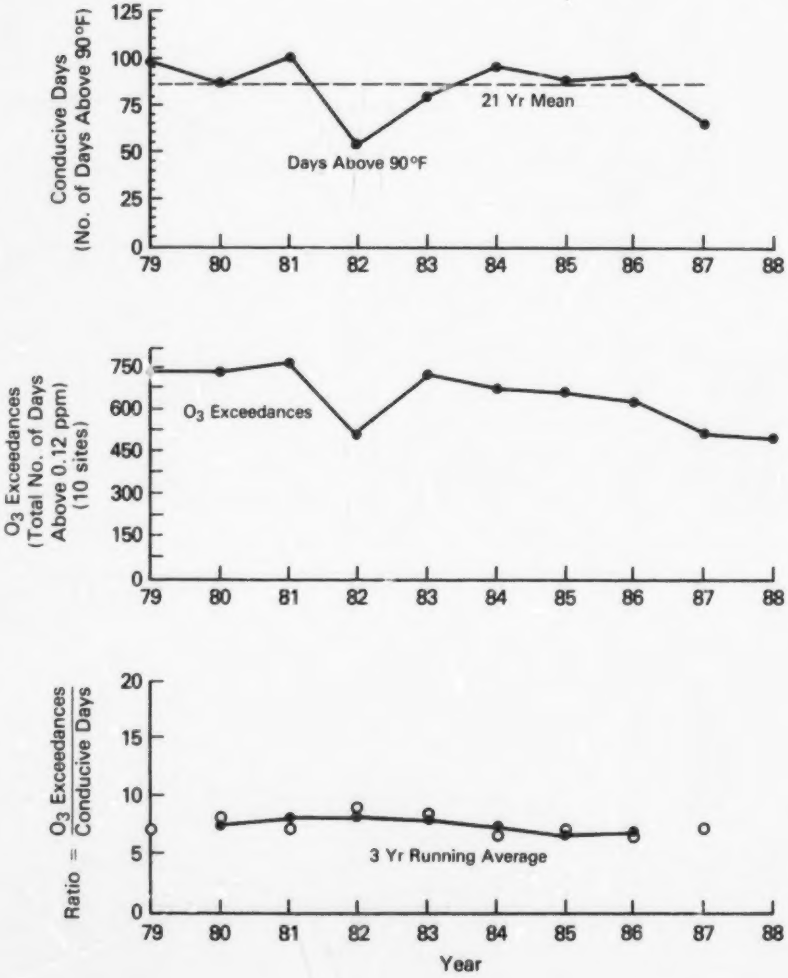


Figure 15. Ozone and Temperature Trends for Miami, FL.

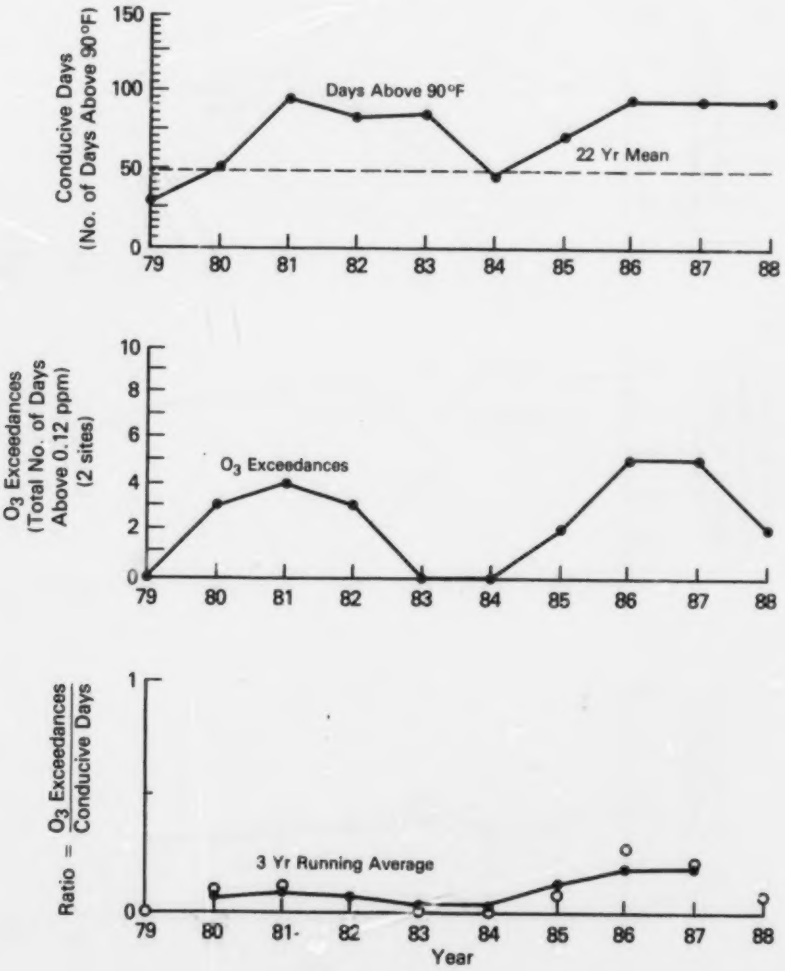


Figure 16. Ozone and Temperature Trends for New York, NY.

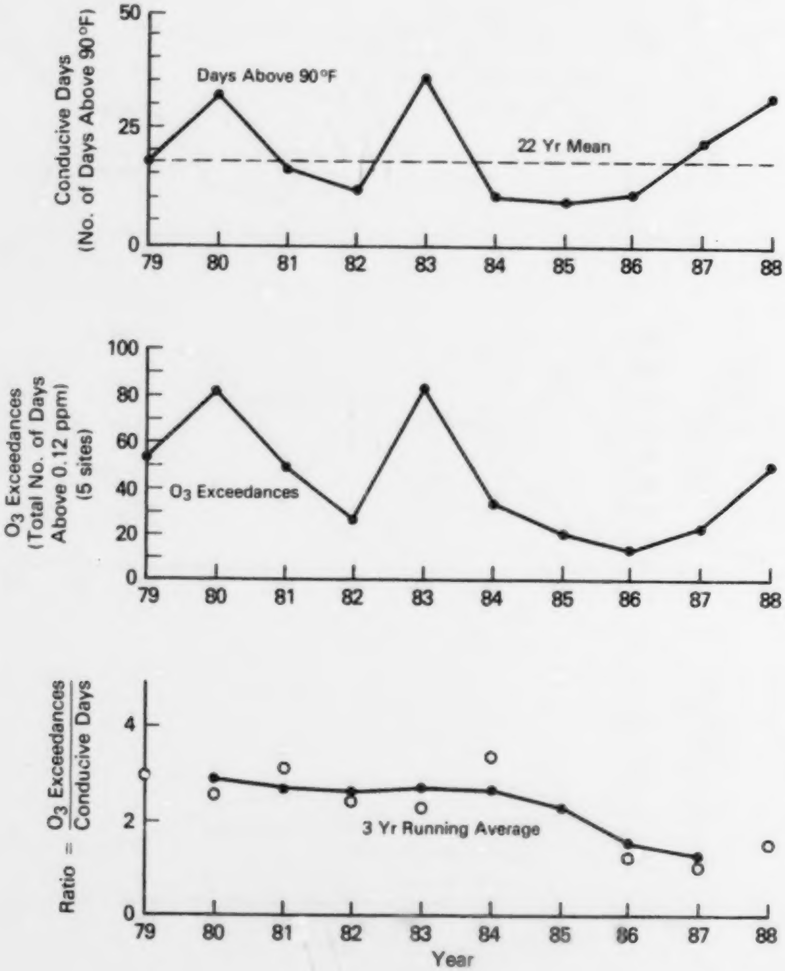


Figure 17. Ozone and Temperature Trends for Philadelphia, PA.

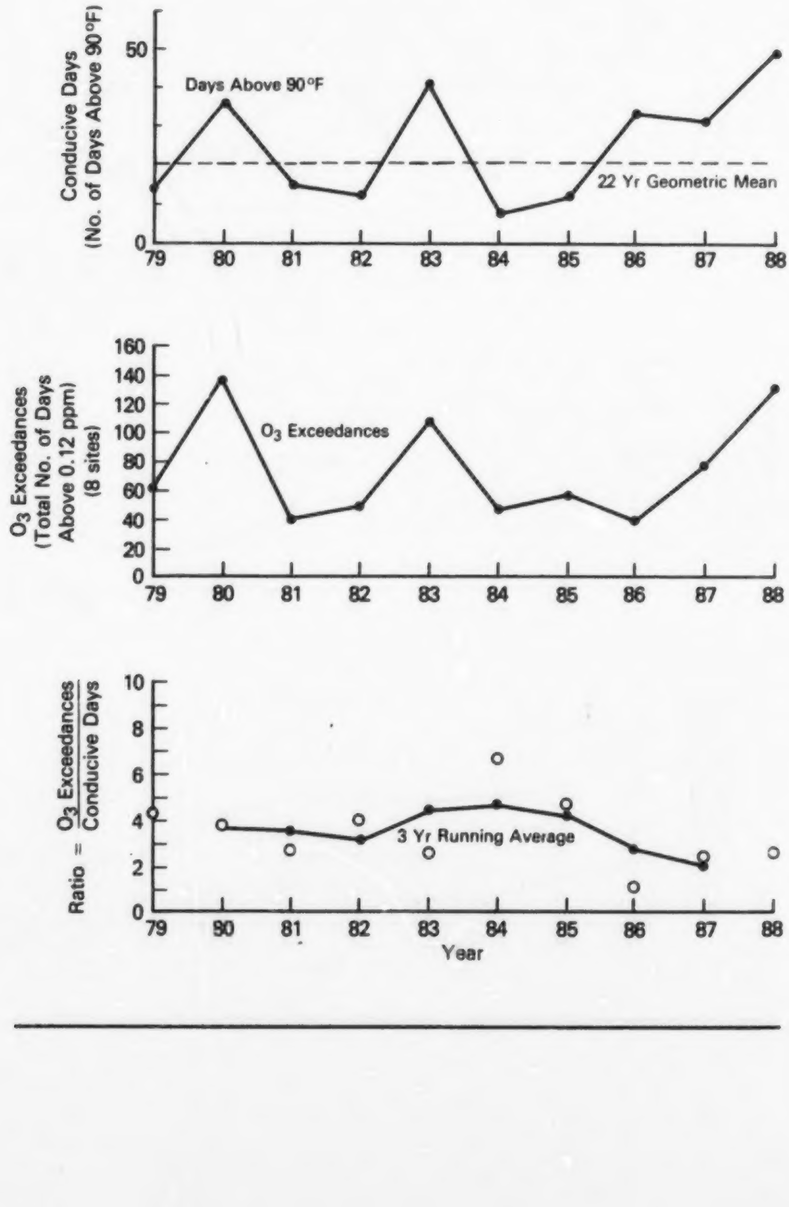


Figure 18. Ozone and Temperature Trends for Phoenix, AZ.

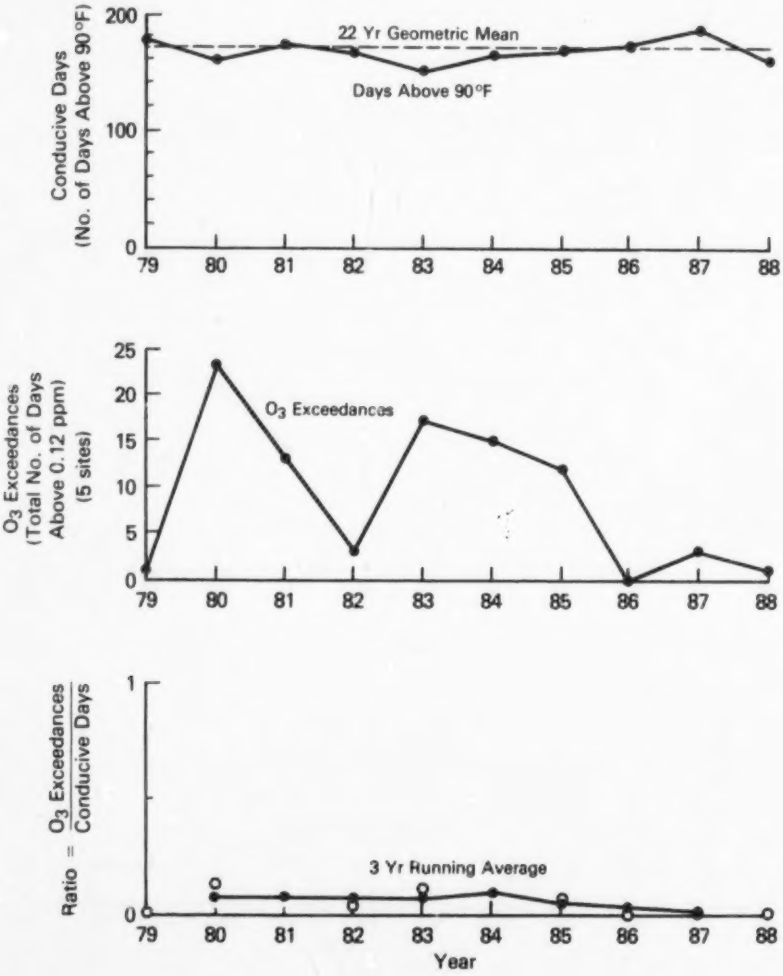


Figure 19. Ozone and Temperature Trends for Portland, OR.

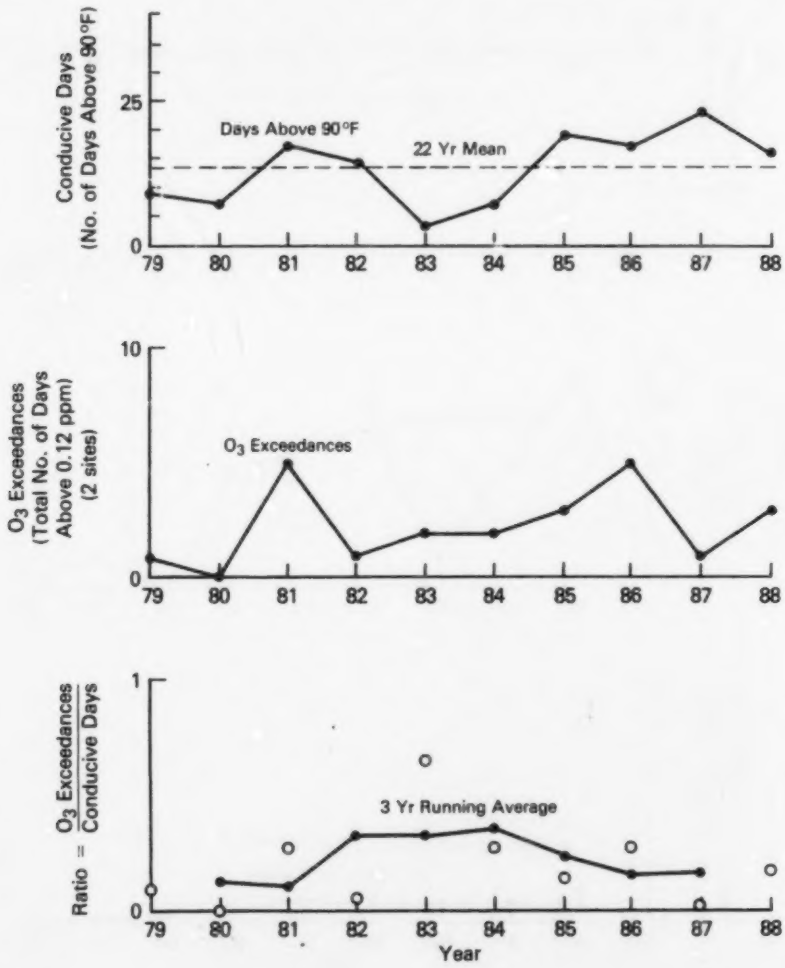


Figure 20. Ozone and Temperature Trends for Salt Lake City, UT.

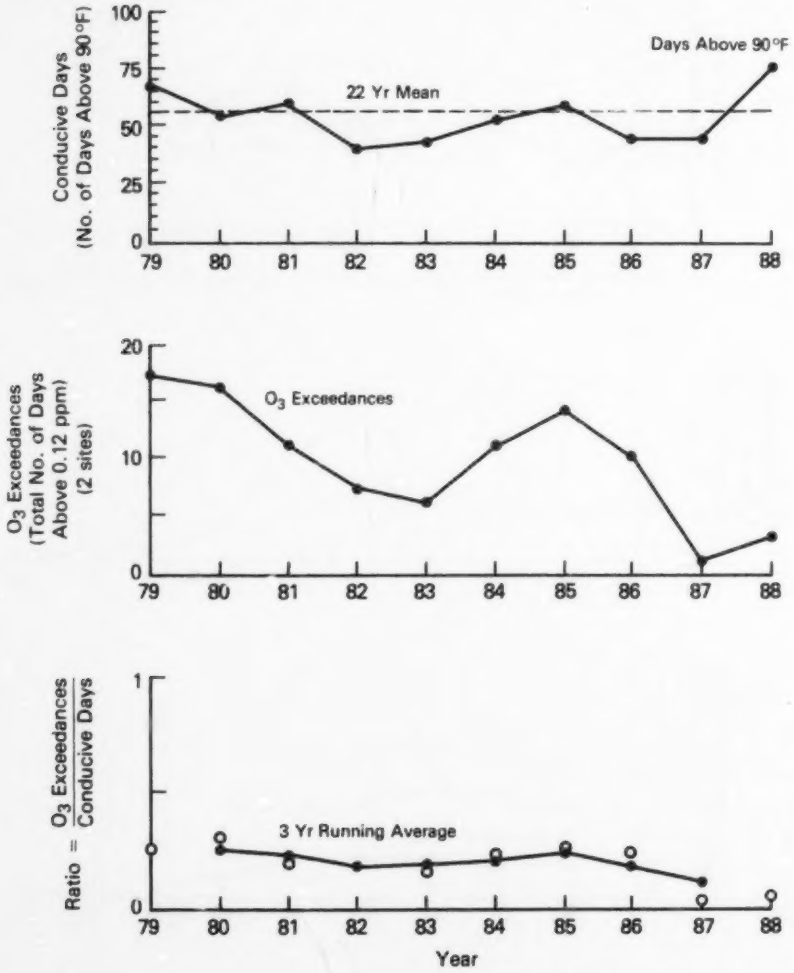
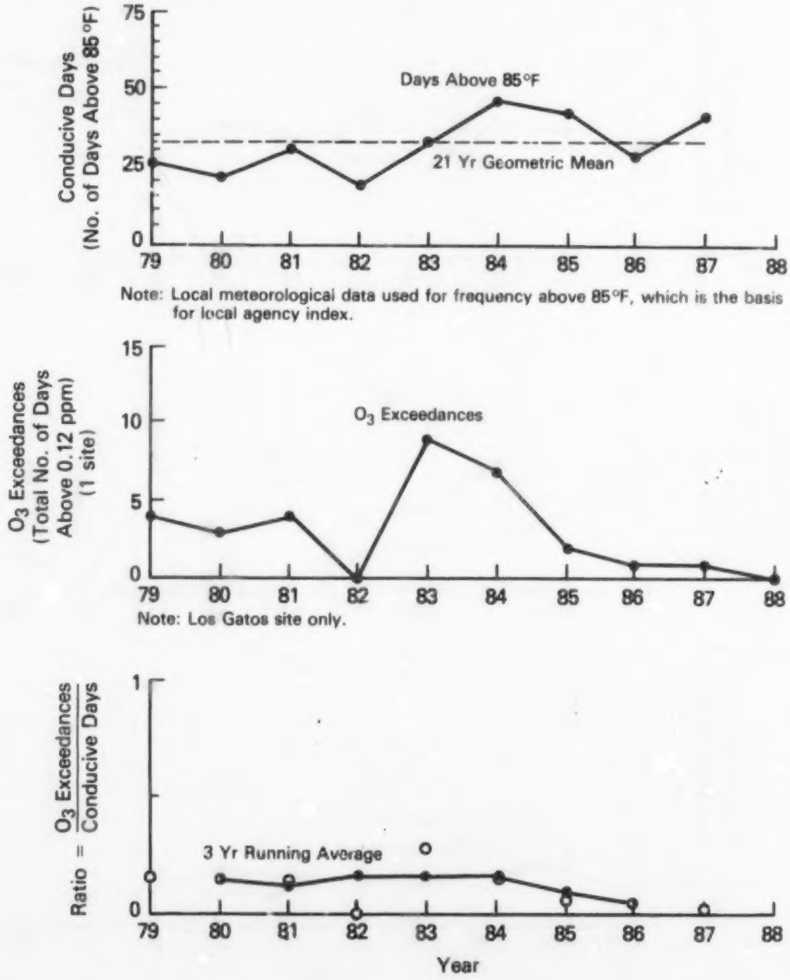


Figure 21. Ozone and Temperature Trends for San Francisco, CA.



Note: Local meteorological data used for frequency above 85°F, which is the basis for local agency index.

Note: Los Gatos site only.

Figure 22. Ozone and Temperature Trends for St. Louis, MO.

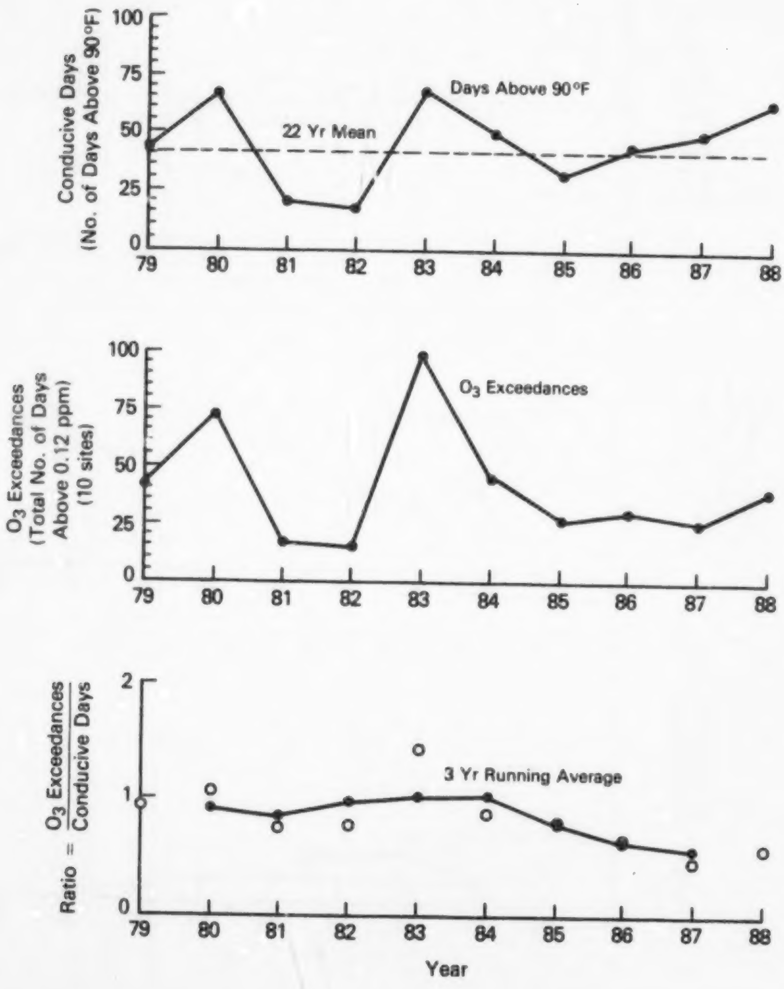


Figure 23. Ozone and Temperature Trends for Tulsa, OK.

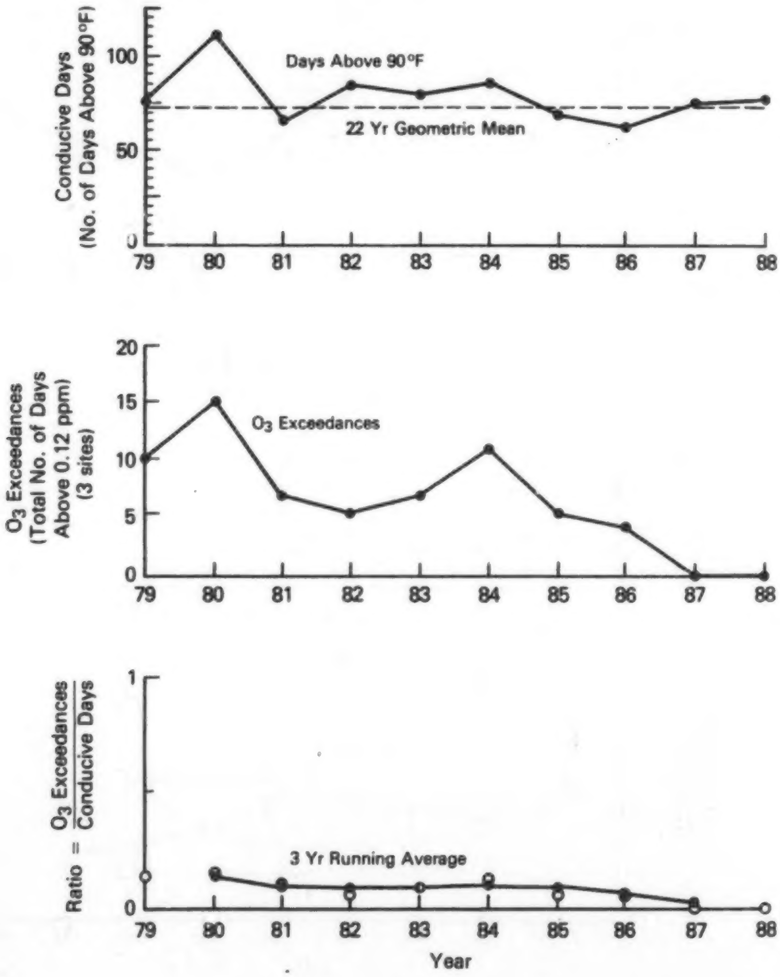


Figure 24. Ozone and Temperature Trends for Washington, D.C.

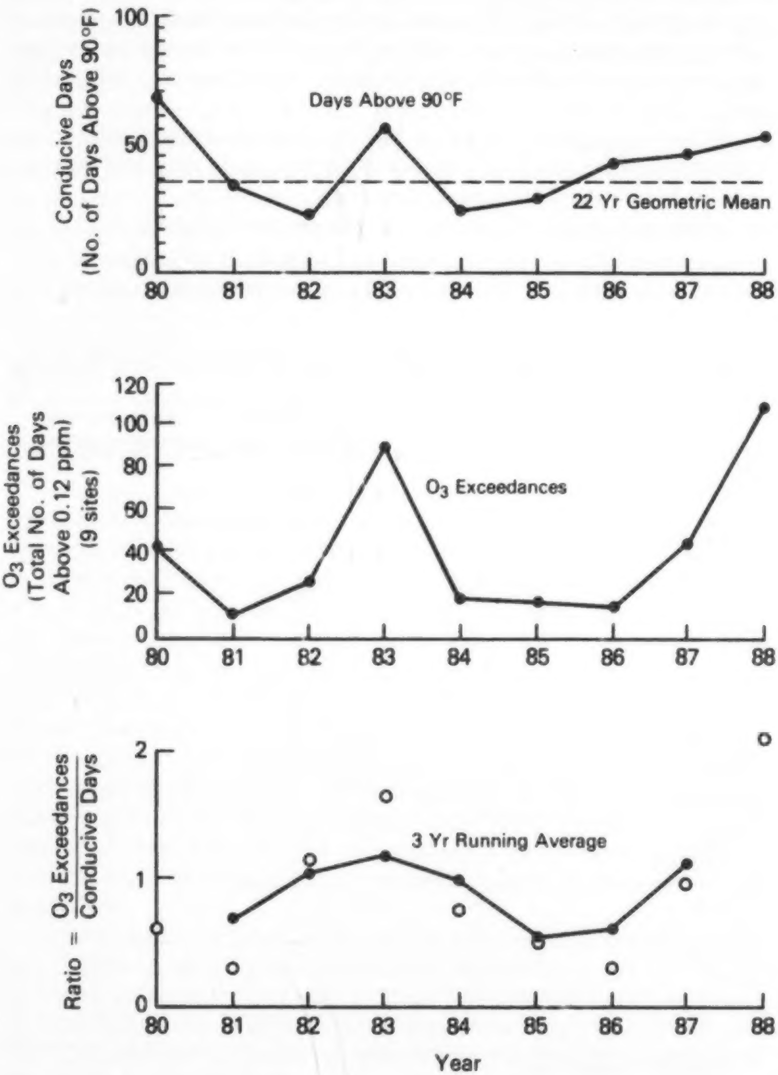


Table 6. Summary of MSW incinerator statistics.

	TOTAL	MODULAR	CONVENTIONAL	RDF
Total facilities	102	51	48	3
With heat recovery	55	31	24	N/A
Total MSW managed (tons per day)	33,541	5,296	26,018	2,227
Total ash generated				
Ash disposed	7,547	1,943	5,374	231
Dry-weight basis	5,191	965	4,027	199
Bottom ash as disposed	2,930	1,630	1,175	125
Flyash as disposed	361	143	114	105
Combined ash as disposed	4,255	169	4,085	0
Number of facilities				
Disposal method				
Onsite landfill	23	12	9	2
Offsite landfill	73	36	36	1
Other/unknown	6	3	0	0
Type of Landfill				
Monofill	36	16	18	2
Co-disposal	41	19	21	1
Other/unknown/not landfill	25	16	9	0
Ash disposed of				
Disposal method				
Onsite landfill	22.78%	3.37%	28.61%	50
Offsite landfill	77.22%	96.63%	71.39%	49
Other/unknown	0.00%	0.00%	0.00%	0
Type of Landfill				
Monofill	35.50%	25.97%	38.30%	50
Co-disposal	17.45%	46.14%	5.70%	49
Other/unknown/not landfill	46.57%	27.89%	55.32%	0

RDF = Refuse-derived fuel

Source: Roffman, Haia K. and Wesley L. Bradford. *Characterization of Municipal Waste Combustor Ashes and Leachates from Municipal Solid Waste Landfills, Monofills, and Co-Disposal Sites*, NUS Corporation and Versar, Inc., for U.S. Environmental Protection Agency, EPA 530-SW-87-028a, Washington, D.C., January 1988.

in Table 2. Where two exceedance rates appear in each column, two sites met the worst case site selection criteria. Where only one exceedance rate appears, the same monitoring site met both selection criteria previously discussed. Seven of the cities analyzed have expected exceedance rates of one per year and nine have 2-5 days above the ozone NAAQS. Los Angeles is all by itself from an impact standpoint. Two other areas had more than 10 exceedances, i.e., Houston, with 14, and Fairfield County, with 12. The regional similarity in impact levels is also evident, with the northeast exhibiting a range of expected exceedances of 3-10 days, while other regions show closer to attainment levels based on CEQ's normalization technique (excluding Los Angeles, Houston and Fairfield County).

As a cross check on this approach, an additional analysis was performed in the following manner. The city by city temperature trends data were examined to determine the most recent year that came closest to being an expected (or normal) year. The actual observed exceedance rates were then recorded. These unadjusted data are shown in Table 3. Despite the fact that

Table 2. Normalized (expected) and observed number of exceedances for the years 1986/1987/1988.

REGION	CITIES	ANNUAL AVERAGE NUMBER OF EXCEEDANCES[1,2] FOR 1986/1987/1988	
		Normalized	Observed
Northeast	New York/Connecticut	7, 3 (12)[3]	9, 5 (16)[3]
	Philadelphia	10, 5	17, 8
	Baltimore	9, 5	13, 8
	Washington, D.C.	7	9
	Boston	5	5
Southeast	Atlanta	6, 5	13, 9
	Louisville	2, 1	3, 2
	Miami	1	2
Midwest	Chicago	5	8
	St. Louis	5, 3	6, 4
	Cincinnati	3, 2	5, 3
	Dayton	1	2
	Detroit	1	2
South Central	Houston	14	15
	Dallas	3	3
	Tulsa	1	1
	Baton Rouge	3	4
Rocky Mt.	Denver	1	1
	Salt Lake City	3	3
Southwest	Los Angeles	115	115
	San Francisco	3, 1	3, 1
	Phoenix	1	1
Northwest	Portland	1	2

[1] Exceedance rates are for the most highly impacted monitoring sites in each city. (See text.)

[2] Data was rounded to nearest whole day.

[3] Data in parenthesis is for Fairfield County, Connecticut.

Table 3. Ozone NAAQS exceedance rates in the most recent year closest to a normal temperature year.

CITY SITES	NORMAL TEMPERATURE YEAR[1]	OBSERVED EXCEEDANCES AT CONTROL SITES
Atlanta	1985	8, 2
Baltimore	1986	12, 4
Boston	1987	4
Baton Rouge	1988 (1987)[2]	3 (5)
Chicago	1986	2
Cincinnati	1986	2, 0
Dallas	1987	1
Dayton	1986	1
Denver	1986	1
Detroit	1986	0
Houston	1986	21
Louisville	1986	4
Los Angeles	1985	117
Miami	1984	0
New York/Connecticut[3]	1987 (1986)[2]	7, 4 (5, 2)[2]
Philadelphia	1987 (1986)[2]	23, 9 (8, 2)[2]
Phoenix	1988	0
Portland	1988	2, 1
Salt Lake City	1985 (1986)[2]	10, 4 (6, 4)[2]
San Francisco	1987	3, 1
St. Louis	1986	5, 2
Tulsa	1987	0
Washington, D.C.	1986	2

[1] Most recent year closest to the expected number of days above 90°F (85°F for San Francisco only).

[2] A second closest year is also illustrated because 1st year closest to normal year showed significant deviation from normal.

[3] For Fairfield County, Connecticut, the observed maximum exceedance rate was 19 exceedances in 1987 and 10 in 1986.

most of the data go back one to two years, and hence were years with higher than current emissions levels, the results confirm the previous analysis. Seven of the 23 cities met the expected exceedance rate criteria for attainment in a "normal" year, with eight other cities showing no more than five exceedances. Only Los Angeles, Houston and Baltimore showed more than 10 exceedances. These comparative data confirmed CEQ's normalized data approach in that both sets of data show excellent agreement.

Temperature Effects on Peak Concentrations

The 1988 drought year brought about not only exceedances of the standard above that expected in many areas of the country, but also much higher than expected maximum concentrations. The most recent 1987 and 1988 data provided by EPA to CEQ reflected this abnormal impact. These data are shown in Table 4, in comparison to data for the last most recent year closest to the expected (or normal) temperature profile for each city. In some cases, the comparable year was still well above normal, i.e., Philadelphia, Miami and for the period of continuous data. The ozone trend indicator is the sum of the annual exceedances at all sites in the metropolitan area, which helps to normalize for wind direction effects. The lower graph represents the quotient of the "hits to opportunities" or "exceedances to conducive" days. The three year running average of this indicator is then determined, to see what the underlying trends in the ozone levels are without the overriding meteorological effect.

Table 1 shows the combined results of the individual city by city analysis. Three approaches were used in examining the trend data. Each city's data was examined to answer the following questions:

1. What is the observed ozone trend including the 1988 data point?
2. What is the observed ozone trend excluding the 1988 data point?
3. What is the observed trend of the data corrected for temperature?

Table 1. City by city trends analysis for exceedances of ozone NAAQS in 23 selected cities.

CITY	RAW TREND WITH 1988	RAW TREND WITHOUT 1988	3-YEAR RUNNING AVERAGE TREND
Atlanta	–	–	–
Baltimore	○	+	+
Boston	+	+	+
Baton Rouge	+	+	+
Chicago	○	○ –	+
Cincinnati	○	+	+
Dallas	+	+	+
Dayton	+	+	+
Denver	+	+	+ (82)[1]
Detroit	+	○	+
Houston	+ (83)[1]	+ (83)[1]	+ (83)[1]
Louisville	+	+	+
Los Angeles	+	+	○
Miami	○	–	–
New York	+	+	+
Philadelphia	+	○	+ (83)[1]
Phoenix	+	+	+
Portland	○	○	+ (83)[1]
Salt Lake City	+	+	+
San Francisco	+	+	+ (83)[1]
St. Louis	+	+	+ (83)[1]
Tulsa	+	+	+
Washington, D.C.	○	○	○
Totals	16 + 6 ○ 1 –	16 + 4 ○ 1 ○ – 2 –	19 + 2 ○ 2 –

+ = Downward (positive) trend
○ = No trend
– = Upward (negative) trend
○ – = Possible negative trend

[1] Data in parenthesis denotes the beginning year of downward trend.

The plus sign (+) indicates an observed improvement, or downward trend in exceedances, while a minus sign (-) indicates an observed deterioration, or upward trend in exceedances. A zero (o) means that no discernable trend up or down can be determined. It is clear from the data based in all three approaches that the national trend has shown distinct improvement over the past decade. The three year running average data shows distinct downward trends in 19 of the 23 cities studied. Seven of the cities did not begin to show the downward trend until 1982 or 1983, for some unexplained reason. However, 1983 was also an abnormally "hot" year, causing higher values in the 3-year running average computations for these seven cities. Only Atlanta, which has been a very high growth city, shows a distinct upward trend. Miami, which is the only other city showing a negative trend by any of the three approaches, does not have a significant ozone problem. In 1988 there were two exceedances at one of the two monitoring sites in Miami and none at the other, despite the fact that there were 75 percent more conducive days for ozone formation than expected.

Air Quality Status Analysis

The same method used for determining the underlying trend in the city by city ozone data can also be applied to the status analysis. In this case, however, a three year normalization procedure was developed to be consistent with EPA's three year evaluation approach, although EPA does not compensate for temperature. The approach here goes beyond the current EPA guideline for determining attainment or nonattainment in the SIP process. The results presented demonstrate how the CEQ approach would affect the observed data. More detailed local correction models might give different results, but the direction of adjustment would surely be the same. Also, this analysis involves examining the current exceedances rates at only one or two sites. The site used should be the same, most highly impacted, site that was used as the baseline for the 1982 SIPs. These SIPs used 1979/1980/1981 data for baseline purposes. However, the recent 3-year sequence of data, which is obviously affected by the 1988 drought, has shown higher impacts at alternative sites in many cases.

In order to deal with such differences, two sites were used in CEQ's "normal year" attainment/nonattainment status analysis. Both the site with the greatest 3-year average exceedance rate in 1979/1980/1981 and the site with the greatest 3-year average exceedance rate in 1986/1987/1988 were examined with respect to their current ozone levels. The most recent three years of data were then normalized for the temperature effect by multiplying the ratio of the 3-year average number of exceedances of 90°F to the normal (or expected) yearly average times the observed 3-year average of the exceedances of the ozone standard. The normalized data are shown by geographical region

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Table 4. Comparison of maximum observed O_3 concentrations and yearly temperature effects, 1988 versus normal year.

		MAX O_3 CONCENTRATION AND TEMPERATURE RATIO				
		NORMAL YEAR			1988	
REGION	CITY	CONC. (ppm)	YEAR	TEMP. RATIO[3]	CONC. (ppm)	TEMP. RATIO[3]
Northeast	New York/Conn.	.21[1]	87	1.22	.24	2.05
	Philadelphia	.20[2]	86	1.65	.22	2.79
	Baltimore	.16[2]	86	1.19	.22	2.00
	Washington, D.C.	.15	87	1.17	.19	1.51
	Boston	.18	87	0.69	.18	1.77
Southeast	Atlanta	.16[2]	85	0.81	.19	1.94
	Louisville	.20[2]	86	1.17	.20	1.79
	Miami	.16[2]	85	1.40	.14	1.76
Midwest	Chicago	.14[2]	86	0.81	.22	2.18
	St. Louis	.21	86	1.02	.16	1.62
	Cincinnati	.16[2]	86	1.19	.19	3.13
	Dayton	.14[2]	86	0.92	.16	3.46
	Detroit	.12[2]	86	0.69	.20	3.38
South Central	Houston	.20[2]	86	1.05	.16	1.11
	Dallas	.13	87	0.99	.14	1.02
	Tulsa	.12	87	1.03	.12	1.07
	Baton Rouge	.17	87	0.93	.20	1.00
Rocky Mt.	Denver	.18	86	0.94	.14	1.40
	Salt Lake City	.13	87	0.80	.16	1.31
Southwest	Phoenix	.12[2]	86	1.03	.13	.96
Northwest	Portland	.17	86	1.31	.22	1.23

[1] A 0.29 ppm value was reported at one other site which was inconsistent with all other data for the region, although the data point was deemed valid by the state agency.

[2] Peak concentrations shown are the maximum possible value taken from the frequency distribution data contained in the Weston Data Bank.

[3] See text for computation method discussion.

Portland, while some of the comparable years were much cooler than normal, i.e., Boston and Detroit. The rest of the cities were within 20 percent of normal in the comparable year. Only five of the 21 cities were within 20 percent of normal in 1988. The ratios of the deviation from the normal annual average number of days above 90°F is given for the two years being compared. In some cases two values are given for the normal year inasmuch as the next closest year was still quite hot in comparison to the normal year.

It can be seen that generally there are significant differences between the maximum observed concentrations in the abnormal 1988 year versus an expected (or normal) year, especially for those cities with the highest observed maximum concentrations in 1988. The rare meteorological event previously discussed is also well illustrated in Table 4. Examples of the very high maximum concentrations on single days in years with very few exceedances are reflected in the 1986 St. Louis data, the 1986 Cincinnati data, the 1986 Denver data and the 1988 Portland data. There were only three exceedances at the peak concentration site in St. Louis, one at the Cincinnati site, three at the Denver site and one at the Portland site.

Implications of CEQ's Analysis

CEQ concludes that the abnormally hot years of 1987 and 1988 brought about exceedances far greater than expected using the 3-year sequence for defining the statistically based standard for ozone. These impacts were experienced in the Northeast, Southeast and Midwest. In those areas where such abnormal conditions were not observed, the exceedances were not different than expected. CEQ has presented one alternative method of accounting for meteorology. As mentioned earlier, other methods could include additional factors that contribute to ozone formation. When this technique was applied to the observed data, those cities with higher than expected temperatures showed lower "expected" exceedance rates after the temperature adjustment was applied. Only seven cities showed adjusted exceedance rates above five days per year. Further, 19 of the 23 cities showed distinct downward trends over the past decade, with only one showing a degradation over this time frame.

The trends in the emissions of hydrocarbon precursors to ozone formation, volatile organic compounds (VOCs), should continue downward in all major urban areas through the mid 1990's. The downward trend is primarily associated with the continuing turnover of the mobile source population to using the low emissions 3-way catalyst technology that was first required in 1981. It takes about 15 years for the automobile population to turn over. After the mid-1990s, without offsetting measures, population growth and increases in auto use are expected to counter such general trends in some areas.

To date, computer models have been used to determine the emissions reduction requirements for any given baseline level of ozone. Ten years of historical air quality and emissions data are now available. These historical trends data should be used to the maximum extent possible in forecasting future ozone air quality when assessing the potential benefits of particular control strategies.

Looking to the Future

The question will be asked: "How do we know that there will not be more 1988 years in the future?" The method for calculating the frequency of occurrence of "hot weather" years is no different than for predicting very rainy years, very cold years, etc. The historical record of temperature can be used to calculate the probability of another 1988. It is exactly the same method as projecting the frequency of floods. Table 5 shows the results of such an analysis for 22 of the 23 cities studied.

Table 5. Probabilities of another 1988 ozone year occurring in the future.

REGION	CITY	RATIO OF DAYS GREATER THAN 90°F (1988/NORMAL)	PROBABILITY OF OCCURRANCE OF ANOTHER 1988 (CHANCE OF RE-TURN, IN YEARS)
Northeast	Baltimore	2.00	1/33
	Boston	1.77	1/18
	New York/Connecticut	2.05	1/7
	Philadelphia	2.79	1/33
	Washington, D.C.	1.51	1/7
Southeast	Atlanta	1.94	1/7
	Louisville	1.79	1/11
	Miami	1.76	1/11
Midwest	Chicago	2.18	1/50
	Cincinnati	3.13	1/50
	Dayton	3.46	1/33
	Detroit	3.38	1/36
	St. Louis	1.62	1/13
South Central	Houston	1.11	1/6
	Dallas	1.02	1/3
	Baton Rouge	1.00	1/3
	Tulsa	1.07	1/3
Rocky Mountain	Denver	1.40	1/7
	Salt Lake City	1.31	1/40
	Phoenix	0.96	2/3
West	Los Angeles	NC[1]	
	San Francisco	1.24 (87)[2,3]	1/5
	Portland	1.23	1/3

[1] Not calculated.

[2] Data not available for 1988.

[3] San Francisco data is for above 85°F.

In those cities, mostly impacted by the hot 1988 year, the likelihood of another 1988 is very low. That is, the higher the ratio of days above 90°F in 1988 relative to the norm, the less likely such an occurrence in the future. This is called the "return period." For example, it would not be anticipated that another 1988 year such as that experienced in Philadelphia would occur for another 33 years, or no more than once during the next 33 years. A return period of one in two means that 1988 was an expected (or normal) year.

Notes and References

1. U.S. Environmental Protection Agency. 1988. National Air Quality and Emissions Trends Report, 1986. Office of Air Quality Planning and Standards, Research Triangle Park, NC. (EPA-450/4-88-001), pp. 3.20-25.
2. "Review of the National Ambient Air Quality Standards for Ozone, Assessment of Scientific and Technical Information," U.S. EPA/OAQPS. Research Triangle Park, N.C., November 1988 (p. VIII-20).
3. Ibid.
4. McCurdy, Thomas and Richard Atherton. "Descriptive Analysis of Ozone Air Quality Indicators in Metropolitan Areas." U.S. EPA/OAQPS, Research Triangle Park, N.C., November 1988.
5. Personal communication with Professors Robert Charlson and John Wallace, Department of Atmospheric Sciences, University of Washington, Seattle.
6. The principal air quality data used in this analysis is taken from the Roy F. Weston Air Quality Data Management System. These data have been extracted from the USEPA's national data bank using the Pollutant Standard Index format. The 1987 and 1988 ozone data were provided by EPA in order the make this analysis as current as possible. The temperature data was obtained from NOAA's National Climate Data Center. In some instances, local agencies and weather stations were contacted to fill data gaps where appropriate.
7. The data presented for 1988 is complete only through August 15. Although the ozone season is usually past by this time in most cities, there may have been some unrecorded exceedances beyond this date. These 1988 data which have been cited by EPA and CEQ have not been through formal quality assurance checks, although errors are rare and should not have any effect on the analysis presented herein.
8. Environmental Quality 1984. 15th Annual Report of the Council on Environmental Quality, Executive Office of the President. 1985. Supt. of Documents, Washington, D.C., pp. 37-39.
9. Ibid. Also, see Bay Area Air Pollution Control District, "Annual Trends Analysis," San Francisco, CA.

Developed Water Resources

3

The inland navigations of the Rivers of these three States [Georgia, South Carolina and North Carolina], may be improved (according to ideas I have formed of the matter) to a very extensive degree — to great and useful purpose and at a very moderate expense compared with the vast utility of the measure; inasmuch as the falls in all of them are trifling and their lengths great.

— George Washington

The development of America's abundant water resources has been key to the growth and prosperity of the United States. Many major cities grew up around rivers and harbors that were developed for navigation or water power. A significant portion of the national wealth, estimated at 10 percent, has been invested in an infrastructure designed to alter the hydrologic cycle for a variety of useful purposes.[1] In addition, economic growth has long been a goal of federal water resources projects, as seen in the commerce along the nation's inland navigation system, the agriculture that became feasible with western reclamation projects, or the regional development spurred by the Tennessee Valley

Authority. Furthermore, federally developed projects have facilitated related development opportunities which, when viewed historically, have stabilized the physical and economic environment of the American landscape. The Tennessee River valley and the lower Mississippi River are regional examples of such trends towards stability.

But water resources development has not been without significant impact on other natural resources. Habitats have been altered resulting in new animal populations and the displacement or loss of former populations. Water quality, related land resources and in-stream ecosystems often deteriorated. Yet, America's growing prosperity has been accompanied in recent years by increasing expectations for environmental quality. Today the development and conservation of water resources rests on full consideration of technical feasibility, economic justification and environmental protection.

This chapter reviews the federal involvement in water resources development, non-federal responsibilities and cooperative efforts. By examining the historical and existing conditions and programs, and recent trends and policies, the chapter provides a record of accomplishment and some insights into future directions regarding the relationship between water resources development and environmental quality, and the partnership between the federal government and non-federal beneficiaries of water resources development projects.

Historical Federal Role

The federal government's role in developing and protecting the country's water resources has evolved as the nation expanded westward. Waterway development came first. Secretary of the Treasury Albert Gallatin's "Report on Roads and Canals" (1808) provided a blueprint for national efforts. Gallatin argued that the federal government alone had the ability and resources to construct certain ambitious, but necessary, projects and insisted that the resulting economic benefits must be understood as "annual additional income to the nation."[2] A decade later Secretary of War John C. Calhoun attempted to persuade Congress of the necessity of federal involvement to develop the nation's waterways for both national defense and commercial expansion.[3]

Navigation

The U.S. Army Corps of Engineers made surveys of the Ohio and lower Mississippi rivers in the early 1820's. In 1824, a General Survey Act authorized the President to use Army engineers to survey road and canal routes "of national importance, in a commercial or military point of view." Appropriations soon followed for improving navigation on the Ohio and Mississippi rivers. This was done by the removal of snags and floating trees. Experiments were initiated on the Ohio river on means to deepen channels across sand and gravel bars.[4]

In the next fourteen years, rivers and harbors acts were regularly passed that extended Corps of Engineers survey and construction work to hundreds of projects. Indeed, throughout the country, construction crews, both public and private, state and federal, were building roads and canals. In 1829 James Fenimore Cooper wrote, "It is only necessary to discover the want of a bridge, or a canal, to insure an effort and commonly a successful one, to bring it into existence."[5]

By the time the Civil War began, the federal contribution to river, harbor and canal improvements amounted to about $17 million in appropriated monies. Some 4.6 million acres of public lands were given for canal improvements and another 1.7 million acres for river improvements. Land grants under the 1849 and 1850 Swamp Land acts and the 1841 Land Grant Act totaled approximately 73 million acres. While these grants and appropriations were not insignificant, they represent a modest amount of aid compared with state and private interest contributions, which totaled well over $185 million for canals alone by 1860.[6]

In the 1880's and 1890's, Congress directed the U.S. Army Corps of Engineers to prevent dumping and filling in the nation's harbors. As an example of early enforcement efforts, at the port of Pittsburgh in 1892, the Corps took a grand jury on a boat tour of the harbor and obtained some 50 indictments of firms that were dumping debris into the harbor. In one Ohio city in 1893, the Corps forced the city to build an incinerator and burn refuse rather than dump the garbage into the river. The garbage, the Corps insisted, was enough to obstruct navigation.[7]

Flood Control

In 1912 and 1913, disastrous floods occurred throughout the Mississippi and Ohio River basins. These floods led to the creation of one of the most successful early flood control organizations, the Miami Conservancy District, above Dayton, Ohio. Led by Arthur Morgan, the District built five reservoir dams between 1914 and 1918, which in the following decades repeatedly proved to be effective flood control structures.[8] The first federal Flood Control Act was passed in 1917. For the first time, the national government accepted certain limited responsibility for flood control in two sections of the country, the lower Mississippi and Sacramento river basins. Hydraulic mining operations had devastated the Sacramento River, creating a situation as life-threatening as existed on the lower Mississippi. While the Act recognized a federal obligation to assist flood victims in the two river basins, it also institutionalized a cost-sharing policy that stipulated that for every two federal dollars spent the local interests would spend one. Since local interests also provided the rights of way for levee construction, their actual share of the cost amounted to about half. Moreover, they had to maintain the levees once construction was completed. The Act authorized the expenditure of $45 million for work on the Mississippi and $5.6 million for Sacramento River work.[9]

In the West, uncontrolled seasonal flooding, particularly on the Colorado River, was an early concern of the Bureau of Reclamation, which provides flood control storage in reservoirs constructed mainly for agricultural and municipal and industrial water uses. An unusually devastating flood hit the lower Colorado in 1905, changing the course of the river, which flowed uncontrolled into California's Imperial Valley for more than a year, and creating the Salton Sea. However, Reclamation's first flood control funding allocations did not come until 1926, and benefits were not calculated until 1950. By then, Hoover Dam had largely controlled the flood flows of the Colorado.

The flooding that finally brought a re-evaluation of policy – and of financing – happened on the lower Mississippi in 1927. Between 250 and 500 people were killed, over 16 million acres were flooded and 41,000 buildings were destroyed. The Red Cross cared for over 600,000 people at one time. The 1927 flood demonstrated that levees alone could not sufficiently control the Mississippi's waters: a mix of levees, floodways and spillways would be necessary. The 1928 Flood Control Act called for the construction of floodways and spillways, channel improvement operations, as well as continued work on levees. It released lower Mississippi residents from all local cooperation requirements except those to maintain certain flood control works after completion, to accept certain lands condemned for the project, and to provide rights-of-way. The reasons given for this federal largess were that the residents of the lower Mississippi had borne enough suffering, they had spent a substantial amount of money on non-federal levee construction, and it was unreasonable to expect them to bear this burden any longer.[10]

Significant federal involvement in nationwide flood control efforts began with passage of the 1936 Flood Control Act, which declared that flood control was a "proper activity of the federal government in cooperation with states, their political subdivisions, and localities thereof." This policy marked the real beginning of comprehensive federal flood control work. As such, it is landmark legislation. The projects that the act and subsequent amendments authorized have literally changed the geography of the United States and have caused or contributed to profound demographic shifts in the nation. They also led to an enormous expansion of the Corps of Engineers civil works mission. The Act emphasized structures – floodwalls, levees and dams – and directed that, before a project could be built, benefits "to whomsoever they may accrue" had to exceed costs. The intent was to protect the population against the sort of disastrous floods that inundated the Northeast and the Ohio River Valley in 1936. Additional serious flooding occurred again in 1937.[11]

Shoreline Erosion

The federal government's first experience with coastal erosion resulted from threats to the foundations of coastal fortifications which Army Engineers constructed in the nineteenth century. Already in 1829, for instance, Fort Moultri, South Carolina, was endangered because of substantial erosion. The Corps had to build breakwaters and jetties to control the situation. An early civil works project was the seventeen-foot seawall the Corps built on the Galveston, Texas, waterfront following a devastating hurricane that struck the city on September 8, 1900, killing 6,000 people.[12] However, a concerted effort in coastal erosion control began only in the 1930's, partly the result of pressure from the newly created American Shore and Beach Protection Association and partly the result of legislation introduced by Senator Walter E. Edge of New Jersey, the state that first showed concern about eroding beaches.

In the 1930 Rivers and Harbors Act, Congress authorized the Corps of Engineers to make cooperative studies of the coast. The states would split the costs of the studies with the federal government. To develop these studies, the Chief of Engineers created a Beach Erosion Board (BEB) within the Corps. Its charge was relatively limited – to examine shore problems only on federal property that related to the coastal navigation works of the Corps of Engineers. Moreover, it could respond to state requests for studies, but could not initiate work or conduct scientific investigations. Without empirical research, data was bound to be insufficient, and physical laws governing coastal change could not be understood. Engineers saw beaches being destroyed and, using prevailing wisdom, looked to structural solutions.[13]

In 1936, Congress passed an act for the "improvement and protection of beaches along the shores of the United States." The law provided for federal assistance for construction, but not maintenance, of shore improvement and protection projects. However, in general the policy was limited to the construction of coastal erosion works only where federal interests were involved. Also maximum federal participation was fixed by executive order at no more than half of the total costs. Meanwhile, the Federal Emergency Relief Administration constructed or improved hundreds of bathing beaches as part of New Deal unemployment relief activity, and the National Park Service experimented with sand dune reconstruction on the Outer Banks of North Carolina.

Irrigation and the Bureau of Reclamation

The Homestead Act of 1862 had been rooted in the idea that 160 acres was the ideal size for a family farm, but it was clear that this size was ill-suited for the region west of the 98th meridian where the average annual rainfall was less than 30 inches and irrigation was essential.[14] In the 1870's Congress struggled to come up with an effective irrigation policy that would satisfy the needs of western farmers.

In 1877 Congress passed the Desert Land Act which provided settlers with up to 640 acres at $1.25 per acre if they reclaimed the land within three years of filing. The following year John Wesley Powell published his widely-circulated report on *Lands of the Arid Region of the United States*. Powell noted that in the arid West — which he defined as the land west of the one hundredth meridian — only three percent of the land or twenty-three million acres could be irrigated with the available water. He encouraged water management through the revision of land laws and the creation of irrigation districts.

To establish policy, the federal government needed detailed information on the current status of arid lands in the West, especially topographical maps. On March 20, 1888, Congress directed the Geological Survey to examine Western states to determine the practicability of storing water for irrigation and building reservoirs with an appropriation of $100,000. The Survey selected and mapped a number of prospective reservoir sites.[15]

Before 1890 there was little demand for federal involvement in irrigation and no strong, well organized irrigation movement. After a drought in 1890 and a depression in 1893, private investors dwindled and western interests began to look to the federal government for capital, although irrigation remained largely private. In 1891, the National Irrigation Congress (NIC) was formed to unite various groups interested in irrigation to devise a program that would win national support. Congress responded to this new political pressure in several ways. In 1891 it halved the acreage requirement and eliminated the residency requirement under the Desert Land Act. At the same time, Congress specifically authorized farmers' associations to go after water.[16] In consequence, irrigation increased slightly. In August 1894 Congress passed the Carey Act which provided that the government would donate up to one million acres of public domain to western states for irrigation and agricultural development. If the state wished, the land could be assigned directly to the farmers and land developers in 160 acre tracts.[17]

The Bureau of Reclamation, originally named the United States Reclamation Service, was created by Congress in 1902 to reclaim the arid lands of the West through irrigation, and to stimulate the settlement and economic development of the region. The mission of the Bureau of Reclamation is to assist non-federal entities and other federal agencies in the 17 western states in developing and conserving the nation's water resources, not only for irrigation but for a variety of other uses by means of environmentally and economically sound water projects constructed to improve the quality of life and stimulate local, regional and national economies.

As the West grew in population and economic stability, Reclamation's original role expanded to satisfy increasing demands for municipal and industrial water supplies, hydroelectric power, salinity control, improved water quality, recreation, flood control and environmental enhancement.

Hydropower

Beginning in the early 1880's, when the first central power-generating station opened in New York City and a plant in Appleton, Wisconsin, first utilized falling water to produce electricity, construction of hydroelectric dams began to proliferate. Many of these private dams threatened navigation. The Rivers and Harbors Act of 1890 and 1899 required that dam sites and plans be approved by the Secretary of War and the Corps of Engineers prior to construction. The General Dam Act of 1906 empowered the federal government to compel dam owners to construct, operate and maintain navigation facilities without compensation whenever such facilities were necessary at hydroelectric power sites.[18]

Private interests developed most power projects before World War I. The Corps of Engineers did install a power station substructure at Lock and Dam 1 on the Upper Mississippi River. The government later leased the power facility to the Ford Motor Company. In 1919, the Corps began construction of Dam #2 – later renamed Wilson Dam – as a hydroelectric facility at Muscle Shoals on the Tennessee River. Support for the facility, which was intended to supply power for nitrate production, declined with the end of World War I, and its completion was threatened. However, by 1925 the project was substantially finished.[19] In April 1930, Secretary of the Interior Ray Lyman Wilbur signed the largest power contract in U.S. history to utilize hydroelectric energy to be generated at Hoover Dam, then under construction by the Bureau of Reclamation. In the 1930's the Bureau also constructed Grand Coulee Dam on the Columbia River, now the largest producer of hydroelectric power in North America and the second largest in the world.

In 1920, Congress created the Federal Power Commission (FPC) to license non-federal hydroelectric plants. The FPC used the Corps of Engineers to examine applications and prepare reports, a laborious and time-consuming task. By 1931, the Corps had completed 276 engineering reports, held 60 hearings and was overseeing 129 licensees.

New Deal priorities shifted the emphasis in federal hydroelectric production. The Coolidge Administration had advocated selling surplus power at federal plants in order to fund other projects. President Franklin Roosevelt wanted to use the surplus power to provide cheap energy as well as to offset costs. During the New Deal, the Corps participated in three major hydroelectric power projects: Passamaquoddy Tidal Power Project in Maine, Bonneville Dam on the Columbia River and Fort Peck Dam on the Missouri River. In 1937, Congress created the Bonneville Power Administration to dispose of the power and set the rates for the power generated at Bonneville Dam.

Tennessee Valley Authority

The Tennessee Valley Authority (TVA), another New Deal enterprise, actually has roots in the earlier conservation period of Theodore Roosevelt. During his administration, a special Inland Waterways Commission had proposed a coordinated plan for developing the resources of the 26-million acre Tennessee River basin. Republican congresses in 1928 and 1931 did attempt some modest legislation in that direction, but first Calvin Coolidge and then Herbert Hoover vetoed the bills. However, on May 18, 1933, Congress responded to Franklin Roosevelt's call for a "corporation clothed with the power of government but possessed of the flexibility and initiative of a private enterprise" and passed the Tennessee Valley Authority Act.[20] TVA was to provide flood control, electric power, navigation, reforestation and economic development to the Tennessee River Valley. It eventually became the nation's largest utility and by the 1980's its annual budget totaled over $5.6 billion with only about $200 million spent on non-power programs.

The Flood Control Act of 1944 empowered the Secretary of the Interior to sell power produced at Corps and other federal projects.

Congress authorized major systems involving hydroelectric power on the Columbia and Snake rivers in the Pacific Northwest, the Colorado in the Mountain West, the Missouri and the Arkansas. A 1955 Hoover commission report estimated that out of a total $14.3 billion federal water resources investment, $3.9 billion was for hydroelectric power generation.[21]

The Postwar Era

In subsequent years, the Army Corps of Engineers, Bureau of Reclamation and Tennessee Valley Authority constructed huge multi-purpose dams that served various needs such as flood control, navigation, irrigation, water supply and hydropower. The scope and impact of the projects called for careful coordination with states and local governments. Requirements for doing so were mandated in the 1944 Flood Control Act. The Fish and Wildlife Coordination Act of 1946 passed less than two years later, requiring federal water development agencies to coordinate with the U.S. Fish and Wildlife Service in order to reduce adverse effects on wildlife resources. This legislation was considerably strengthened in 1958, when President Dwight D. Eisenhower signed an Act that specified that fish and wildlife conservation receive equal consideration with other project purposes.[22]

Water Supply

Lieutenant General Samuel D. Sturgis, Jr., the Chief of Engineers in the mid-1950's, was convinced that the Corps had the capability to address the growing water supply problems of the nation. He advocated that all Corps reservoirs constructed for river control include water supply storage. However, legislation was necessary. Such legislation would make the explicit point that water supply would remain primarily a non-federal responsibility, but that the federal government should cooperate and support local efforts by modifying existing projects, providing for an equitable repayment schedule and addressing water supply problems in federal water studies and investigations. The Water Supply Act of 1958 (P.L. 85-500, July 3, 1958) authorized the Corps to include municipal and industrial water supply storage for present and future demand at any Corps reservoir project, provided that state and local interests give assurances that they will use the storage and repay the costs allocated to water supply within the life of the project and within 50 years after water supply storage is first used. This act is the primary vehicle for federal involvement in water supply storage. Water supply storage remains a major element of multi-purpose management of federal water projects.

Intergovernmental Cooperation and the Kerr Committee

Beginning with the 1936 Flood Control Act and continuing into the Eisenhower Administration, the principal justification for water projects remained national economic development. However, President Eisenhower stressed that no matter how justified projects were, the federal treasury did not contain limitless funds. Eisenhower asserted that the best natural resources program would not result from exclusive dependence on the federal bureaucracy. It would involve a partnership of the states and local communities working together with federal agencies.[23]

Eisenhower was certain that such a partnership would lead to both cost and operational efficiencies. He particularly insisted that federal involvement in hydropower development should be limited. On the other hand, the federal government was prepared to assume major design and construction responsibilities whenever large multi-purpose projects were justified but beyond the capacity of non-federal interests.[24]

While the notion of partnership was implicit in many of the Executive Branch proposals of the 1950's, the most important step towards its realization came with the establishment of the Senate Select Committee on National Water Resources in 1959. Chaired by Senator Robert S. Kerr of Oklahoma, the Committee held hearings throughout the country on a variety of subjects relating to water development.

The Committee's 1961 report made five major recommendations that stressed greater cooperation between the federal government and the states, more scientific research on water, biennial assessment of water supply demands and greater promotion of water development efficiencies, including non-structural measures.[25] The report led to a number of developments in the water resources field.

Recreation and Environmental Quality

An explosion in recreational visits to federal lands and developed facilities in the years following World War II led to the establishment of the Outdoor Recreation Resources Review Commission (ORRRC) in 1958 to study the present and future of outdoor recreation in the United States. The ORRRC's final report made in 1962 emphasized that outdoor recreation was a fundamental part of American life and suggested the importance to a growing urban population of access to recreation sites, including reservoirs. The Bureau of Outdoor Recreation (BOR) was established within the Department of the Interior to act as a clearinghouse for federal involvement in recreation development, and subsequently conducted many comprehensive water resources recreation planning studies for federal water agencies.

While the ORRRC was preparing its report, the Senate Select Committee on National Water Resources was working on its own. The Select Committee's report urged the development of recreation at all federal reservoir projects, not just the Corps'. These initiatives led to some important policy changes. The 1962 Flood Control Act authorized the Corps to construct, operate and maintain recreational facilities at any of its water resource projects, not just reservoirs. That same year, Senate Document 97[26] contained new interagency standards for water resources project planning. Drafted by the Secretaries of Interior, Agriculture, Army and Health, Education and Welfare at the request of President Kennedy, the document shows the obvious influence of the Kerr Committee report. The new standards required that all views be heard – federal, state and local – prior to formation of project proposals. Multi-purpose projects were to be preferred over single purpose, and all projects were to be formulated in light of overall river basin plans. Recreation and water quality were to be considered as project benefits in the same way as navigation, hydropower, flood control, irrigation, water supply, watershed protection and fish and wildlife enhancement.[27]

The Federal Water Project Recreation Act, passed in 1965, made this new policy law. It elevated recreation to the same primary benefit status as other, more traditional, benefits. Under this legislation, recreation helped justify project development, although the law stipulated that the federal government could bear no more than one-half the cost of recreation development. Also, local interests must bear the full cost of operation, maintenance, and replacement. However, Corps projects authorized before 1965 were excluded from the cost-sharing requirement, as were TVA and SCS projects.

By the early 1960's, a number of experts came to question the country's reliance on structural flood control projects. The problem was twofold. The projects often provided a false sense of security and in some cases encouraged unwise development in flood plains. The alternative was non-structural measures such as zoning, flood forecasting, flood evacuation and flood proofing. House Document 465, published in 1966, recommended a "unified national program" for managing flood losses that would include information on non-structural measures.[28] One result of the increased interest in flood plain management was the creation of an office within the Army Corps of Engineers to assist local communities to evaluate flood hazards and develop appropriate programs to reduce the risk of flood losses.

The nation's growing concern over environmental deterioration steadily intensified during the 1960's, and in 1969, Congress passed the National Environmental Policy Act (NEPA). President Nixon signed it on New Year's Day, 1970. NEPA, the first important piece of legislation of the environmental era, established the Council on Environmental Quality and required federal agencies to consider environmental effects in decision making and to prepare environmental impact statements in recommendations and decisions for major federal actions "significantly affecting the quality of the human environment." President Nixon directed all Executive Branch agencies to bring their procedures and policies into compliance with NEPA.[29]

The Federal Water Pollution Control Act Amendments of 1972 gave the U.S. Environmental Protection Agency (EPA) the responsibility for the permitting of pollutant discharges into the nation's waters. At the same time, the Act (Section 404) gave the Army Corps of Engineers the responsibility for the permitting of the discharge of dredged or fill material into the waters of the United States. The 1972 Act also authorized $18 billion to assist municipalities in constructing wastewater treatment facilities. From then to the end of 1988, some 18,800 grants have been awarded, with the federal contribution of $50.5 billion; non-federal sources have contributed an additional one-third of this amount in matching funds for grant-eligible projects, and additional amounts for land and other, non-eligible portions of these facilities.

Principles and Standards Revised

In 1973, the Water Resources Council, which had been established eight years earlier, published *Principles and Standards for Planning Water and Related Land Resources*. These "Principles and Standards," or P&S as they were called, were to be used by all federal water resources agencies in formulations of federal water projects. They included consideration of economic, environmental, social and regional issues.[30] The Water Resources Council revised the P&S in 1980, including then an Environmental Quality Evaluation Procedures to parallel Procedures of Evaluation of National Economic Development Benefits and Costs, and increasing the emphasis on non-structural measures for water resources projects.[31] During the latter part of the 1970's, the P&S were very useful in ensuring a broad perspective was used in water resource remainder coming from non-federal interests such as states, port authorities and local communities. A total of 377 new water projects were authorized for construction or study. This includes 43 port projects, seven inland waterway projects, 115 flood control projects, 24 shoreline protection projects and 61 water resources conservation and development projects (such as for fish and wildlife mitigation). In addition, the Act authorized 38 special studies, 63 project modifications and 26 other miscellaneous projects and programs.

Although the number of projects and studies authorized in WRDA 86 is significant, its policy changes will have more impact. Together they substantially modify the approaches to the planning and financing of Corps projects which evolved over the last half- century. Revisions in cost sharing requirements, the imposition of ad valorem cargo taxes to maintain harbors, increases in inland waterways fuel taxes to support lock and dam projects and various other reforms will result in greater participation by states, ports, waterway interests and local communities in both the financing and designing of water projects.

The implementation of these policy changes, the cost sharing requirements and specific studies or programs was guided by John Doyle, Principal Deputy Assistant Secretary of the Army for Civil Works, who had been intimately involved in the drafting of WRDA 86. The magnitude of this effort was large because of the long time lapse from the last previous authorizing bill. To avoid repeating this, to re-establish a two year cycle for priority considerations and authorizations, and to extend the period for some special programs, WRDA 88 was proposed by the Reagan Administration. It became law in November 1988. The goal of WRDA 88 is to reinforce and extend the consensus on cost sharing as the appropriate way to finance federal water projects.

At the direction of Robert W. Page, who succeeded Dawson in 1987 as Assistant Secretary of the Army for Civil Works, the Corps of Engineers has been rewriting its planning procedures to include the non-federal project sponsors, principally states and local communities, as full partners in the project development process. More accurate cost accounting systems are being developed, and each project will have its own project manager or management team to insure a quality planning, engineering and construction effort. The entire planning process will be revised to insure that projects are thoroughly reviewed without unnecessary delays. There is a strong commitment to efficient, customer-oriented service. At the same time, private, state and local efforts will be needed to insure an adequate water resources infrastructure into the next century.

It is fully expected that the policy reforms of WRDA 86 will yield more economically efficient and environmentally sensitive projects. The results to date look very encouraging. Because non-federal sponsors must pay a portion of project costs, project designs have more closely reflected true needs, projects have been reduced in scale or are being phased in over longer periods of time. The result is not only economic efficiency but also reduced environmental impacts. For this reason private environmental groups were key supporters of the compromise which yielded WRDA 86 and have continued to support its reforms.[36]

Conditions and Trends

The Institute for Water Resources of the Army Corps of Engineers, in a report for the National Council on Public Works Improvements, has identified 13 water resources functional service areas. They are ports, inland waterways, flood control, urban drainage, dam safety, shoreline protection, irrigation, hydropower, agricultural drainage, streambank protection, fish and wildlife and recreation, municipal water supply and wastewater treatment. In recent years a clear and equitable distinction of areas of federal and non-federal responsibility for these functions has been reestablished. Ports, inland waterways and flood control are traditional responsibilities of the federal government and, as noted earlier, the Reagan Administration forged a compromise with competing interests to allow those programs to go forward in an economical, environmentally sound manner. For most of the other areas, there is a recognized need for federal assistance through technical criteria and advice, but the principal responsibility for implementation of projects rests with state, local, or private interests. The areas of urban drainage and streambank protection are fully non-federal responsibilities.[37]

Federal water resources development programs are divided among many agencies, but four predominate: the U.S. Army Corps of Engineers, the Bureau of Reclamation (BuRec), the Soil Conservation Service (SCS) and the Tennessee Valley Authority (TVA). Of the roughly $3.8 billion spent by all four agencies in 1987 for water resources development, the Corps accounted for slightly over 70 percent, the Bureau about 21 percent, the SCS 8 percent and the TVA 1 percent.[38] These relative shares have been fairly constant for the past two decades. The Corps has predominated in spending for inland waterways, commercial harbors and urban flood control and the Bureau of Reclamation has lead in irrigation projects. Both, plus the SCS, participate in rural flood control efforts. (See Figure 1.)

Impressive as those numbers are for demonstrating the value of federal water development investments, the total is about equal to that spent for programs in wastewater, groundwater and hazardous waste site treatment. The Environmental Protection Agency has the principal role in establishing standards and criteria for water quality, and in providing funding assistance for wastewater treatment facilities and hazardous waste site cleanup.

nificantly eroding; this includes about a third of the Great Lakes shorelines and 43 percent of the conterminous oceanic coastline. The total investment in shoreline protection projects, about $360.1 million, includes the structural protection of 336.3 miles.

■ 7. **Irrigation**. This service area enhances crop production. Currently, about 13 percent of the nation's cropland, some 58 million acres, are irrigated. In certain areas of the arid and semi-arid west, irrigation enables dependable and diverse agricultural production and provides a stable economic base.

■ 8. **Hydropower**. Hydropower facilities offer a clean, efficient and reliable source for energy. However, because of economic competition from fossil fuels, the portion of electricity generated from hydropower has declined from 15 percent in 1970 to 12 percent in 1986. A continued decline is expected but additional development opportunities do exist.

■ 9. **Agricultural Drainage**. Agricultural drainage is a practice whereby excess water is removed from soils to improve agriculture. The practice is primarily conducted by local governments and private interests. Currently, about 80 million acres have been drained for agriculture.

■ 10. **Streambank Protection**. Streambank protection features are installed in localized areas where bank failure endangers buildings, transportation routes and property and where sediment deposition from streambank erosion has become a significant problem. Streambank protection is typically included in projects that provide flood control. About 2 percent of the nation's 7 million bank-miles are estimated to be seriously eroding.

■ 11. **Fish and Wildlife and Recreation**. Water resources projects and facilities often displace these classes of environmental and social benefits, but also create new opportunities for them. Increasingly, efforts are made to identify and take advantage of opportunities to enable water resources facilities to serve these benefits.

■ 12. **Municipal Water Supply**. Water resource development for urban settings must focus on water quality as well as supply. Significant patterns of water resource transfer from agriculture to municipal water supply have accompanied the demographic shift of the country's population and promise to be the basis for contested transfer demands in the future.

■ 13. **Wastewater Treatment**. Some 37 billion gallons of wastewater per day is treated by approximately 16,000 municipal wastewater treatment facilities. These facilities serve about 70 percent of the population, and also treat wastes from industrial and commercial establishments.

Navigation

Since the River and Harbor Act of 1824, the federal government, through the Secretary of War and later, Secretary of the Army, has been responsible for initial and maintenance dredging of federally authorized shipping channels, including the primary access channels, through the anchorages, turning basins and harbor areas. The Army's responsibility also includes the construction of general navigation works (e.g., breakwaters, jetties, etc.). The Coast Guard provides aids to navigation and search and rescue support, while the Maritime Administration provides subsidies for the U.S. flag fleet in the areas of construction, repair and operation. The federal government assumes responsibility for inland waterways channel and structures.

Both federal and non-federal entities expend large amounts of capital each year to develop and maintain the port and inland waterways infrastructure systems. Army Corps of Engineers appropriations on deep-draft navigation have increased from $408 million in FY 1980 to $583 million in FY 1988.[39] On average, about 70 percent to 80 percent of those funds were for operation and maintenance with the remainder for construction and rehabilitation. Meanwhile, the Corps' expenditures for inland waterways have remained fairly constant during the 1980's, increasing moderately from $690 million in 1980 to an estimated $768 million in 1988.[40] During this period the components of inland expenditures shifted in importance, with operations and maintenance growing to a 59 percent share of the total while construction declined to 41 percent of inland investments.

Total federal obligations for navigation from 1975 through 1987 are summarized in Table 2. Most dredging and capital investment is performed by the Corps of Engineers. Coast Guard obligations fund aids to navigation, marine safety, search and rescue operations and enforcement of laws and treaties. The Maritime Administration funds vessel research and development, shipbuilding and operating differential subsidies, and training of merchant seamen. Other federal agencies providing services to navigation are the Saint Lawrence Seaway Development Corporation (SLSDC) and the National Oceanic and Atmospheric Administration (NOAA).

Table 2. Estimated federal obligations for navigation, by agency (in millions of 1988 dollars).

AGENCY	1975	1980	1985	1987
Corps of Engineers	1,385.5	1,667.5	1,336.2	1,313.5
Coast Guard	1,148.8	1,694.6	2,133.4	2,050.3
Maritime Administration	812.3	662.6	1,028.1	1,011.4
Others (NOAA, SLSDC)	4.7	19.8	35.7	22.0
Total	3,373.0	4,044.5	4,533.4	4,397.2

Source: U.S. Army Engineers Institute for Water Resources, 1988.

According to the Maritime Administration, there are 188 deep-draft ports (over 25 feet deep) located along the Atlantic, Gulf, Pacific and Great Lakes coasts, 88 of which handle over two million tons of commerce annually.[42] In total, U.S. ports handled 1.3 billion tons of cargo in 1987. At these 188 ports are public and private commercial facilities, including 1,840 terminals with 3,020 berths.[43] An additional 450 coastal and Great Lakes small boat harbors are maintained by the Corps of Engineers for commercial and sport fishing, general recreational boating and for use as harbors of refuge.

There are 11,000 miles of fuel taxed shallow-draft waterways (less than 14 feet deep) in the U.S.[44] These include those improved and operated by the federal government. The government levies a fuel tax on inland waterway operators to fund construction and rehabilitation of inland navigation projects. The inland waterways are used by a commercial fleet of over 5000 towboats and 34,000 barges to transport over half a billion tons of traffic annually.[45]

The Corps has constructed a total of 1,553 navigation projects and maintains 557 harbors and nearly 12,000 miles of navigation channels. It dredges in excess of 300 million cubic yards of material annually with Corps and contact dredges. There are currently 22 new harbor projects authorized for construction with a total estimated cost of about $915 million. Major federal infrastructure facilities on the inland waterway system include primary navigation channels, 188 locks and dams (with 225 chambers), river training works, bridge pier protection works, mooring facilities and aids to navigation.

According to estimates by the Army Corps of Engineers, the replacement costs of federal port projects would be about $48 billion, (1988 dollars) with $39 billion associated with coastal ports and channels and $9 billion for the Great Lakes system.[46] The replacement value of public and non-public land side deep-draft port facilities are estimated at $98 billion (1988 dollars) by the Maritime Administration.

Disposal of Dredged Material

To maintain and improve these activities, the Corps dredges in excess of 300 million cubic yards of material annually. It also regulates under its permit authority 100 to 150 million cubic yards dredged annually by other federal, state or private entities. Such volumes would cover an area the size of the District of Columbia to a depth of about seven feet, and are comparable to the annual sediment load brought to the Gulf of Mexico by the Mississippi River. About half of the dredged material is disposed of along the coasts or in the open ocean. About 30-40 percent is disposed of in upland sites. Some three to five percent does not meet water quality criteria for open water disposal and is placed in upland confinement areas or placed underwater and capped with clean material to isolate any potential contaminants.

In 1985, a Memorandum of Understanding (MOU) was developed between the National Oceanic and Atmospheric Administration and the Department of the Army under which the National Marine Fisheries Service and the Corps of Engineers are investigating means by which their programs can be mutually supportive in restoring or developing coastal wetlands and fisheries habitat. The experience of the regional Fisheries Management Plans, shows that coastal habitat for spawning and recruitment appears to be a limiting element for some fisheries. A three year pilot program for habitat improvement, involving four projects developed under the MOU, was completed in 1988. The final report is scheduled for 1989.

Dredged material is often used for renourishment of beaches. Two other beneficial uses of note are for the restoration or creation of wetlands, and for the construction of island habitats. Between 1974 and 1984, a total exceeding 19,294 acres of fresh, brackish and salt marsh had been built by the Army Corps of Engineers; over 10,000 acres using dredged material. By the end of 1984, some 2,000 islands had also been created from dredged material, particularly along the Intracoastal Waterway. Such habitats are important to birds, for feeding, resting and nesting and to many species of small mammals. In North Carolina, it has been estimated that 99 per cent of all wading and sea birds nest on dredged material. The relative protection of an island habitat is particularly important for some endangered bird species.

Flood Control

About 6 percent of the land area of the conterminous United States is prone to flooding and nearly 21,000 low-lying communities have flood problems. Floods cause about 10 times more deaths, on the average, than any other natural hazard[47] and account for 90 percent of the disasters declared by the President. Flooding on the lower Mississippi in 1927 alone accounted for an estimated loss of life of between 250-500 people. Since 1975, flood related deaths have averaged 150 persons annually, with a high of 304 in 1986.[48] Estimated damages have risen steadily to about $3 billion annually.

Thousands of small and large flood control structures have been built during the past two centuries. Flood damage prevention benefits from federal flood control projects range from a high of $49.3 billion (1988 dollars) in 1979 to a low of $1.2 billion ($1988) in 1981. Average annual flood damage prevention benefits during the period of 1975-87 are $17.5 billion ($1988).[49]

Although seasonal runoff throughout most of the West was average to below average in 1987, Bureau of Reclamation reservoirs prevented downstream flooding that would have caused an estimated $52.6 million in damage. This 1987 total benefit is the lowest since 1977; the 38-year average annual benefit is $211.1 million for the 1950-1987 period. Cumulative benefits since 1950 totalled $8 billion in 1987 — almost 7 1/2 times the estimated control or irrigation works to that date.[54] More recently Poertner estimated that, as of 1978, the nationwide investment in surface drainage facilities was about $60 billion ($98.4 billion in 1988 dollars).[55] Specific elements included in these estimates were not made explicit, thus making comparisons difficult, but the general trend over time is that increasing investments are being made. This continues to be an area generally considered to be a local responsibility.

Agricultural Drainage

Agricultural drainage is the practice of using drainage systems, either surface or subsurface, for the purpose of lowering the water level in soils to increase agriculture production. It is estimated that about 150 million acres of land has been drained at least once since 1855. Today the cropland and hayland in the United States total about 421.4 million acres. Some 106.9 million of these acres are wet, and about 80 million of those are considered adequately drained for optimum crop production. The 1982 Natural Resource Inventory by the U.S. Department of Agriculture estimates a remaining agriculture drainage "need" of 27.4 million acres, in addition to necessary repairs or replacement of existing drainage facilities.

Historically, federal funds were used to assist these efforts, but since 1965 there has been little such direct assistance. The "swampbuster" provisions of the Food Security Act of 1985 have further extended the withdrawal of federal financial support from programs which would result in the conversion of wetlands.

Shoreline Erosion

Today, nearly half of the United States population lives in coastal counties. The shoreline population is six times as dense as the rest of the country's. Many areas have experienced population increases that are nothing short of phenomenal. Miami Beach had a population of 644 in 1920, 28,000 in 1940 and 90,000 in 1980.[56] Aided by the automobile and shorter work weeks, coastal resorts and vacation spots have become commonplace in twentieth-century America.

Yet the coastline is receding. About 86 percent of California's coastline is receding at an average of between 0.5 and two feet per year. Louisiana has shrunk by 300 square miles since 1970. Barrier islands have been particularly hard hit. Between 1955 and 1975, the amount of developed land on barrier islands jumped by 153 percent. About 70 of the 195 barrier islands on the Atlantic and Gulf coast have been urbanized, and today the number of residents per square mile on barrier islands is four times the national average. However, communities that once faced broad seashores now are only yards from the ocean. As the barrier islands roll landward – following geological laws –

and as wind, storms and tidal action rip away at the islands, more and more communities are in danger.[57]

There are about 2,700 miles critically eroding shoreline in the United States, of which 1,810 miles are privately owned.[58] Coastal erosion along the Atlantic Coast and along the Gulf Coast is aggravated by subsidence of coastal lands.

Structural solutions to shoreline erosion include direct protection (construction of walls or stone covers on the shore), and indirect protection (construction of groins, which are walls built perpendicular to the shore, or off-shore breakwaters). Non-structural solutions include relocation of endangered residents or structures, regulation of future development and the creation or recreation of protective beaches. Beaches absorb energy and protect the near shore land, but they also may erode, or move as a result of natural forces.

Since the early 1970's, Congress has passed a number of laws to protect the nation's shores and beaches. The Coastal Zone Management Act of 1972 declared it a national policy to "encourage and assist the states to exercise effectively their responsibilities in the coastal zone through the development and implementation of management programs to achieve wise use of the land and water resources of the coastal zone, giving full consideration to the ecological, cultural, historic and aesthetic values, as well as the needs for economic development." Under the provisions of this act, the National Oceanic and Atmospheric Administration (NOAA) has granted over $500 million to states to develop shoreline management programs. Approximately ten percent of these funds have been expended on shoreline erosion problems. Continued congressional interest in shoreline problems was reflected in passage of The Water Resources Development Act of 1974, which contained a measure providing for comprehensive coastal zone planning.

A major coastal protection initiative was the Coastal Barrier Resources Act (CBRA) approved by President Reagan on October 18, 1982. Its aim is to eliminate federal expenditures for developmental activities in high risk areas on Atlantic and Gulf coast barrier islands and to reduce loss of fish and wildlife. In these areas, which include approximately 725 beach front miles, the federal government will no longer subsidize the construction of bridges, roads, various public works such as water and sewer lines. After October 1, 1983, new structures built in the designated areas were not eligible for federal flood insurance. The legislation appears to be successful in preventing or severely limiting commercial and residential development of these undeveloped regions, for without some assurance of federal contributions towards shore protection projects, development appears too risky to be justified.[59]

Streambank Erosion

Streambank erosion is a critical problem along 142,000 of the nation's 7,000,000 miles of streambank.[60] Damages along the critical reaches are estimated to cause more than $300,000,000 damage per year (1988 dollars).[61]

Federal involvement in streambank erosion is significantly different from coastal erosion. For the most part, streambank erosion has been viewed traditionally as a non-federal responsibility.

However, Public Law 83-566 (the Watershed Protection and Flood Prevention Act) and subsequent amendments authorized the Soil Conservation Service to develop the Small Watershed Program to reduce flood damages, protect watersheds and manage agricultural, municipal and industrial water. Soil erosion prevention, including streambank stabilization, is a part of this program.

The Corps of Engineers constructed "demonstration" streambank erosion projects under the authority of The Streambank Erosion and Control Evaluation and Demonstration Act of 1974, but Corps involvement now is limited to technical advice and "Section 14" projects. Section 14 of the 1946 Flood Control Act provides an emergency authority to the Secretary of the Army to plan, design and constructs, small streambank erosion prevention projects to protect structures which are located along streambanks and which are open to public use.

The Bureau of Reclamation is undertaking corrective measures for streambank erosion caused by peaking power operations below Grand Coulee Dam.

Irrigation

The nation experienced a severe drought in 1988, judged to be one of the worst since the extended drought of the 1930's. Agricultural losses were substantial, but manageable limits were maintained primarily because of emergency measures and the substantial proportion of agriculture that is irrigated. Of the approximately 220 million acres of prime cultivated farmland in 1982, 60.5 million acres (29 percent) are irrigated.

Bureau of Reclamation projects provide the vast majority of federal irrigation capability. Reclamation project facilities include 355 reservoirs and dams, and thousands of miles of canals, pipelines and tunnels. Since the program's inception, the federal government has invested approximately $9.4 billion in completed Reclamation facilities of which about 80 percent is reimbursable to the federal treasury. Across the West, Reclamation annually supplies more than 10,000 billion gallons of water to nearly 26 million people for municipal, industrial and agricultural uses. Project water is delivered to more than 10 million acres of farmland to produce crops valued at $8 billion annually.

The expansion of irrigated agriculture based on the availability of inexpensive water has slowed in the West. Depletion of ground water supplies, rising cost of obtaining groundwater, pumping costs, high costs and limited sites for new surface water developments, and the low value of water for irrigation relative to other off-stream uses are among the factors that have led to a leveling off or decline in irrigation in some areas of the West.[62] These trends are likely to continue into the next century.

From the federal perspective, Reclamation's original mission to construct large, federally financed irrigation projects soon will be virtually completed. With this in mind, in October 1987 Reclamation announced a redirection of the agency's mission, shifting the emphasis from water resources development to water resources management. This approach is consistent with the nation's changing priorities for high quality water and the accompanying necessity for more effective, efficient conservation and management of its water resources.

Water Supply

Water for society's many purposes generally requires large offstream withdrawals. Municipal and industrial water supply, agricultural water supply and thermoelectric power cooling are the major offstream uses of water.

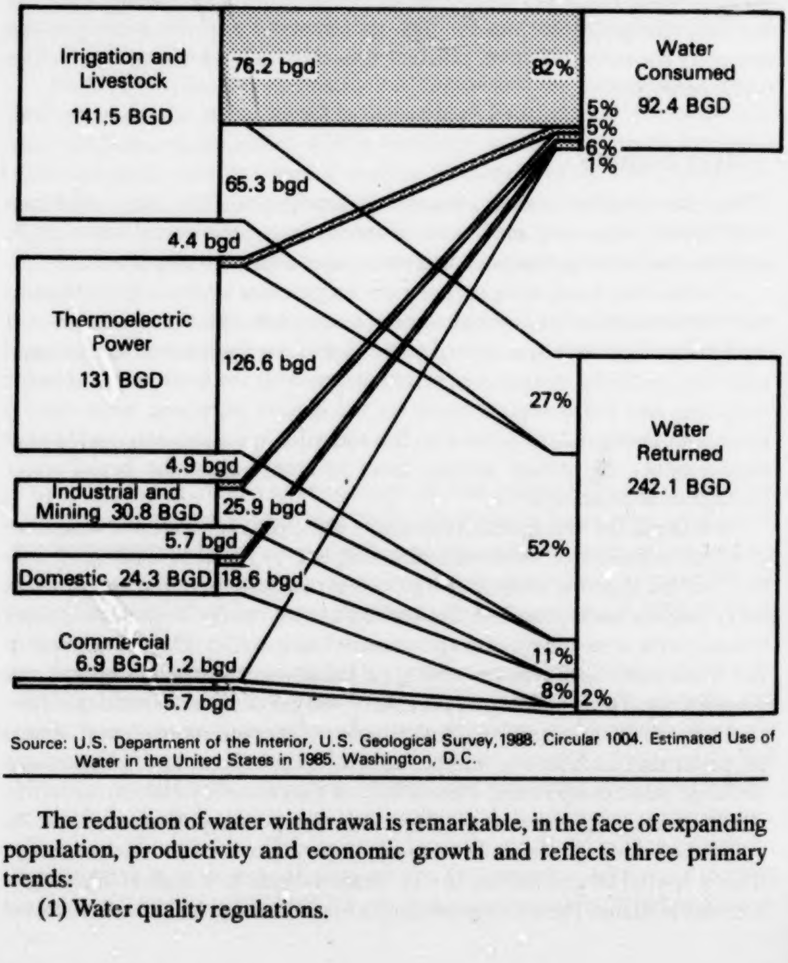
On the other hand, many uses of water require that it remain in the streams and rivers, and thus are somewhat more compatible with the maintenance of aquatic ecology. Instream uses of water include navigation and recreational activities. Artificial storage, i.e., reservoirs, provide the basic mechanism for balancing and redistributing water for the diverse purposes; water quality standards, instream flow criteria for fish and wildlife maintenance and habitat requirements for critical species serve to complement the broad water management objectives.

A sense of the averages and variability of supply and use is provided in an excellent summary of water statistics compiled by the U.S. Geological Survey.[63] Of the approximately 18,000 gallons of rainfall that, on the average, falls every day for each person in the United States, nearly 70 percent quickly returns to the atmosphere as evaporation or transpiration. Of course, much of that water sustains the natural ecological habitat and timber and agricultural productivity. The remaining 30 percent (5,400 gallons person per day) of the precipitation comprises the nation's 9 inches of average annual runoff. This is the water that finds its way into our streams after evaporation, groundwater recharge and transpiration. Nearly half of that runoff, however, occurs in Alaska, leaving approximately 2,700 gallons per person per day available for use in the "lower 48" states. In contrast, average per capita water use ranges from a low of 68 gallons/day in the Virgin Islands to a high of 22,000 gallons/day in Idaho. The average per capita freshwater use for the entire United

States is 1,400 gallons/day, or about one half of the available runoff. Three states used more than 10,000 gallons per capita per day, while 29 states used between 1,000-10,000 gallons of freshwater daily for each person.[64]

Overall, 338 billion gallons of fresh water were withdrawn daily in 1985, along with 60.3 billion gallons daily of saline water.[65] It is important to note that, for the first time, freshwater withdrawals have decreased from a high of 380 billion gallons per day in 1980,[66] representing a decrease of more than 10 percent. (See Figures 2 and 3).

Figure 2. 1985 Freshwater Withdrawals and Disposition of Water in billion gallons per day (bgd)

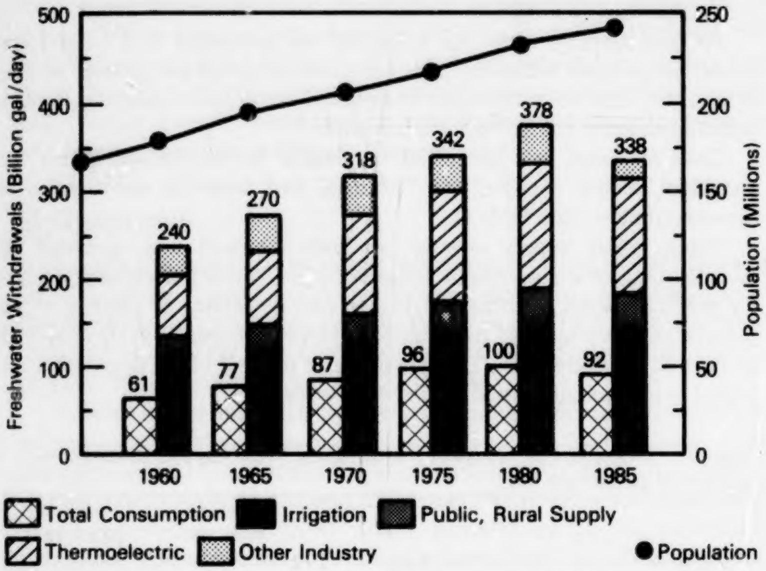

Irrigation and Livestock
141.5 BGD
76.2 bgd
82%
65.3 bgd
Water Consumed
92.4 BGD
5%
5%
6%
1%
4.4 bgd
Thermoelectric Power
131 BGD
126.6 bgd
27%
Water Returned
242.1 BGD
4.9 bgd
Industrial and Mining 30.8 BGD
25.9 bgd
5.7 bgd
52%
Domestic 24.3 BGD
18.6 bgd
Commercial
6.9 BGD
1.2 bgd
11%
5.7 bgd
8%
2%

Source: U.S. Department of the Interior, U.S. Geological Survey, 1988. Circular 1004. Estimated Use of Water in the United States in 1985. Washington, D.C.

The reduction of water withdrawal is remarkable, in the face of expanding population, productivity and economic growth and reflects three primary trends:

(1) Water quality regulations.

Figure 3. Trends in U.S. Freshwater Withdrawals and Consumption, by Use, 1960-1985.



Source: U.S. Department of the Interior, U.S. Geological Survey, 1988. Circular 1004. Estimated Use of Water in the United States in 1985. Washington, D.C.

(2) Water conservation and technological improvements.

(3) User-pay principles and pricing of water-related services.

The percent of the population served by self-supplied water has fallen from 31 percent of the population in 1955 to 17 percent in 1985. Water utilities spent an average of $5 billion annually from 1977 to 1983 to replace and expand water supply facilities.[67]

The Congressional Budget Office has estimated that utilities will spend $5.9 billion annually from 1984 through 2000 for water supply needs.[68] About 60 percent of this amount will be used to replace existing facilities; the remainder will provide facilities for expanded service. In addition, municipalities will be forced to find alternative means of satisfying increasing water demand.

Public water supply utilities and rural water uses for homes and commercial establishments accounted for 10.4 percent of total water withdrawn and 7.5 percent of United States' water consumption in 1985. Public water supply systems provided water to 200 million people in 1985; the remainder of the population (42.5 million) was served by its own water systems, mainly wells.[69]

Per capita use of publicly-supplied water, which includes domestic, commercial (e.g., car washes) and industrial uses, averaged 183 gallons per day across the United States. Per capita use of self-supplied domestic water averaged 105 gallons per day in 1985.

Publicly-supplied water for industrial use amounted to 5.7 bgd from public systems also. Industrial users, especially, supplied a far greater volume of water for their needs through self-supplied withdrawals amounting to 22.8 bgd of fresh water and 3.5 bgd of saline water.

Total historical and projected freshwater in the United States for municipal central supplies and industrial and domestic self-supplies is presented below. (See Table 4).

Public water supply systems are either owned and operated by municipalities or are investor or privately owned. About half of these systems are publicly owned or community water systems serving 67 percent of the population; the other half are investor or privately-owned, but serve only 15 percent of the population. The remaining 18 percent of the population are served by individually owned groundwater wells.

Table 4. Estimated U.S. freshwater withdrawals, historical and projected (in millions of gallons per day).

WATER USE AND SOURCE		HISTORICAL		FOREST SERVICE PROJECTIONS	WATER RESOURCES COUNCIL
	1975	1980	1985	2010	2000
Municipal Central Supplies					
Groundwater	10,800	11,700	14,900	24,100	
Surface Water	18,800	22,300	21,800	34,600	
Total Municipal	29,600	34,000	36,700	58,700	34,650
Industrial Self-Supplies					
Groundwater	9,700	10,300	4,650	6,400	
Surface Water	28,600	28,700	19,810	23,600	
Wastewater	170	190	140	400	
Total Industrial	38,500	39,200	24,600	30,400	30,997
Domestic Self-Supplies					
Groundwater	2,670	3,260	3,250	4,800	
Surface Water	130	180	80	60	
Total Domestic	2,800	3,340	3,330	4,860	2,400

Note: The sum of totals by use and by water source differ because of independent rounding of individual entries.

Source: Data for 1975 through 1985 from U.S. Geological Survey Circulars. Data for 1985 from preliminary unpublished estimates furnished by the U.S. Geological Survey. Projections are U.S. Forest Service (1988) and U.S. Water Resources Council (1978) estimates.

Per capita domestic use rates for municipal systems declined to 105 gallons per day from 120 gpd in 1980, a significant reduction in a few years. Renovations in water systems conducted by municipalities that reduce water leakage and household water conservation measures may account for the change.[70] Water use per unit of production steadily declined between 1954 and 1985 in most major industries that were self-supplied due in part to efficiencies achieved by complying with federal and state water pollution legislation which restricts discharge of untreated water. Future freshwater withdrawals by industry will remain flat or decline.[71]

Hydropower

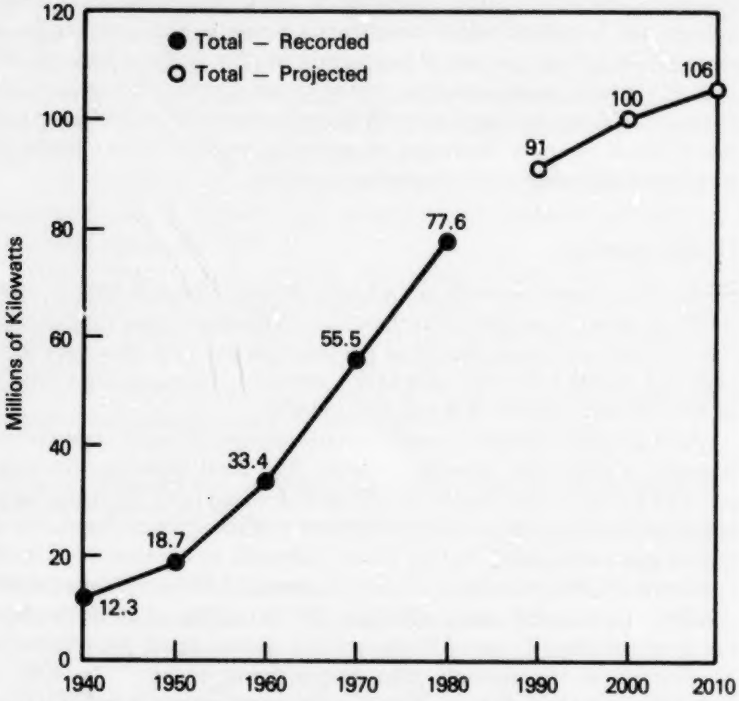
Hydroelectric power capacity in the United States is about 88,000 Megawatts (MW), or about 12 percent of the nation's total electrical generating capacity. The capacities of Corps, Bureau of Reclamation and TVA plants are 20,000 MW, and 13,400 MW and 4,900 MW respectively. Municipalities installed 18,400 MW, while utilities developed 29,350 MW.

Another way of measuring hydroelectric energy is in terms of power used (energy), rather than capacity (power). The total hydroelectric energy generated in the United States in 1985 was estimated to be 296,000 gigawatt-hours (millions of kilowatt-hours). The State of Washington accounted for the largest generation, with 76,900 GWH, followed by Oregon with 38,900, California (32,000), New York (31,000), Arizona (13,900) and Idaho (11,700). Together, these seven states accounted for 73 percent of all hydroelectric energy production. Corps of Engineers hydropower plants produced about 30 percent of the nation's total hydroelectric energy.[72] In 1987, 50 hydropower plants on Bureau of Reclamation projects generated 44.9 billion kilowatt hours of electric energy, enough to serve 14.7 million people. Reclamation power plants had returned more than $5.9 billion to the federal treasury by 1987.

Growth of hydroelectric power capacity is expected to be about 1-2 percent a year in the near future, or about half the rate of the growth in total electrical generating capacity in the United States. Figure 4 shows the actual and expected growth in hydropower capacity from 1940 to 2010. The reduction in the price of oil since the late 1970's, stricter environmental controls on operation and the fact that the most promising sites have already been developed all contribute to the decline in growth.

The energy crisis of the 1970's and the emphasis on clean and renewable energy resources turned the nation's attention to hydroelectric power. Many saw an opportunity to utilize many of the 60,000 existing dams without hydropower as a means of reducing our dependence on imported oil. There was a rush to obtain FERC licenses by private developers. The number of FERC licenses grew from about 500 in 1978 to over 1700 today, mainly be-

Figure 4. Forecast of All Hydroelectric Power Capacity to the Year 2010.



Source: U.S. Army Engineer Institute for Water Resources, 1983. National Hydroelectric Power Resources Study. Fort Belvoir, VA.

cause of the high oil prices of the mid 1970's and the expectation that oil prices would rise to as high as $80 a barrel in the 1980's. Ultimately, however, the increase in capacity was small, since the best sites had already been developed.

Fish and Wildlife and Recreation

Effective management of natural resources at water resources projects has enhanced the outdoor recreational opportunities at these projects. Visitors are attracted to these projects by the experiences that water resources projects offer. They come to fish, boat, water ski, sail, swim, sightsee, hunt, hike, camp, or picnic.

Through its involvement in the planning, design and construction of multipurpose reservoir projects, channels, levees, shore protection measures and inland waterways, the Corps of Engineers is one of the federal government's largest providers of outdoor recreation opportunities, second only to the

USDA Forest Service. (See Table 5.) The Corps administers over 4400 recreation areas at 463 lakes and waterways on the 11.4 million acres of land and water it manages across the nation. Of this total, 2544 areas are managed by the Corps and 1841 areas are managed by states, counties, cities, towns and other federal agencies. These projects reported a total of 501 million recreation visits in 1987, a six-fold increase over the last 30 years. While water is one feature that makes many Corps projects particularly attractive to the public, location is another. About 80 percent of these projects are within 50 miles of major metropolitan areas and 94 percent are within a two hour drive.

Table 5. Visitation to recreation areas, by agency (in thousands of visitor hours).

AGENCY	TOTAL VISITATION
Forest Service	2,861,499.6
Corps of Engineers	1,784,192.0
National Park Service	1,393,912.6
Bureau of Land Management	517,186.0
Bureau of Reclamation	381,395.0
Tennessee Valley Authority	78,095.2
Total	7,016,280.4

Source: U.S. Department of the Interior, National Park Service. Federal Recreation Fee Report 1987. (Washington, D.C.: NPS, 1987).

Water quality at federal reservoirs is considered to be good, but is dependent on conditions within the watershed. All Corps of Engineers reservoir projects are included in water quality management programs, with extensive coordination with federal and state regulatory and resource agencies. Specific water quality objectives are established for each project. Throughout the year, water quality measurements are evaluated against these specific project objectives. When the water quality objectives are not met, various remedial actions are taken for both the reservoir and the downstream areas below the dam:

- oxygen injection into reservoir waters to increase dissolved oxygen;
- aeration of the reservoir by induced mixing;
- modification of mixing and water temperature by use of selective withdrawal structures;
- modification of reservoir operating procecures; and
- management and control of upstream point source pollution.

The Bureau of Reclamation controls 6,131,396 acres of land and 1,729,419 acres of water surface in 17 western states; the TVA, 420,000 acres of land and 640,000 acres of water managed for recreation and other purposes. The 286 recreation areas on Reclamation projects accommodated 53.1 million visitors planning. However, they normally resulted in reports that were long, difficult to follow, and difficult to use as a decision document.

On March 1, 1983, President Reagan approved "Principles and Guidelines" (P&G) to replace the old P&S. The new P&G streamlined the project planning process and ensured decisions yielding the greatest economic return on investment, "consistent with protecting the nation's environment, pursuant to national environmental statutes, applicable executive orders and other federal planning requirements."[32] The P&G recognize that federal agencies carry out their work in conformity with myriad laws, numerous Executive Orders and agency regulations, which taken together ensure a full range of environmental considerations.[33]

Over 50 federal statutes include environmental quality provisions applicable to federal water resources projects. Of those, 17 statutes contain specific action forcing standards or other requirements to protect the environment. (See Table 1.)

Table 1. Major environmental statutes applicable to water resources development projects.

1. National Environmental Policy Act of 1969; PL 91-190; 42 USC 4321 et. seq.
2. Clean Water Act of 1972, as amended; PL 92-500; 33 USC 1251 et. seq.
3. Coastal Zone Management Act of 1972, as amended; PL 92-583; 16 USC 1451 et. seq.
4. Wild and Scenic Rivers Act of 1968, as amended; PL 90-542; 16 USC 1271 et. seq.
5. Water Resources Development Act of 1986; PL 99-662; 33 USC 2201 et. seq.
6. Food Security Act of 1985; PL 99-198; 16 USC 3811 et. seq.
7. Clean Air Act of 1977, as amended; PL 95-95; 42 USC 7401 et. seq.
8. Coastal Barrier Resources Act of 1982; PL 92-348; 16 USC 3501-3510.
9. Endangered Species Act of 1973, PL 93-205; 16 USC 1531.
10. Fish and Wildlife Coordination Act of 1958, as amended; PL 85-624; 16 USC 661.
11. Marine Mammal Protection Act of 1972, as amended; PL 92-522; 16 USC 1361.
12. Marine Protection, Research, and Sanctuaries Act of 1972; PL 92-532; 33 USC 1401.
13. Archeological Resources Protection Act of 1979; PL 96-95; USC 470.
14. National Historic Preservation Act of 1966, as amended; PL 89-665; 16 USC 470.
15. Archeological Data Conservation Act of 1974; PL 93-291; 16 USC 469.
16. Native American Religious Freedom Act of 1978; PL 95-341; 42 USC 1996.
17. Reservoir Salvage Act of 1960; PL 86-523; 16 USC 469.

Source: U S. Water Resources Council, 1983. Economic and Enviornmental Principles and Guidelines for Water and Related Land Resources Implementation Studies. Washington, D.C.

Projects may not proceed unless they are in compliance with all of these requirements, and assure that applicable environmental quality standards are attained.

Water Resources Policy Reform — The 1980's

For 16 years from 1970 to 1986, no major water resource project authorization act was enacted. The United States was changing and many of the biggest water projects had either been built or were well on their way to completion. Equally important, an increasingly urbanized, diversified society had many other interests to compete with irrigation, navigation and flood control. Recreation, environmental preservation and water quality became important public issues.

The need for rehabilitating or replacing an aging water resources infrastructure was undeniable by 1980. A number of locks on the Ohio, Upper Mississippi and Columbia Rivers were found to be too old (about 40 years), deteriorated and too small to serve modern shipping. The waterway situation appeared particularly urgent in light of the energy crisis. Both new locks and deeper ports were needed to handle the transportation and exportation of coal and other energy supplies.[34] With increasing demands on the federal budget, as well as growing concerns about the costs and environmental effects of various projects, a way had to be found to eliminate marginal projects while responding to legitimate water resource needs in an equitable, efficient and environmentally sound manner.

Congress had actively considered cost sharing at least since the days of the Carter Administration. A 1978 Act had reversed the traditional approach to navigation improvements, which placed the entire financial burden on the federal government, by establishing a waterways user fee for commercial traffic. The door to cost sharing had been opened. The first Assistant Secretary of the Army for Civil Works in the Reagan Administration, William R. Gianelli, laid the groundwork for a broader policy of reasonable cost-sharing for all water projects. His successor, Robert K. Dawson, finalized the legislative compromise with the Congress in 1986 that insured the revival of a responsible, environmentally sound water resources program.

Water Resources Development Act of 1986

On 17 November 1986, the Water Resources Development Act of 1986 was approved by President Reagan.[35] More simply called WRDA 86, the Act signifies major shifts in the nation's attitude towards water resources planning. The legislation reflects general agreement that non-federal interests can and should shoulder more of the financial and management burdens, that environmental considerations are intrinsic to water resources planning, and that marginal projects must be weeded out.

WRDA 86 authorized $16.23 billion in spending for water projects, of which the federal government would pay approximately $12 billion with the

Figure 1a. Federal Spending for Water Resources in 1988 (Estimated 1988 Outlays of $4.15 Billion).

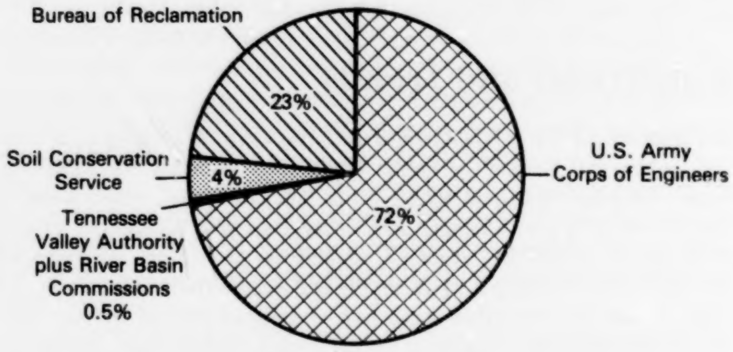
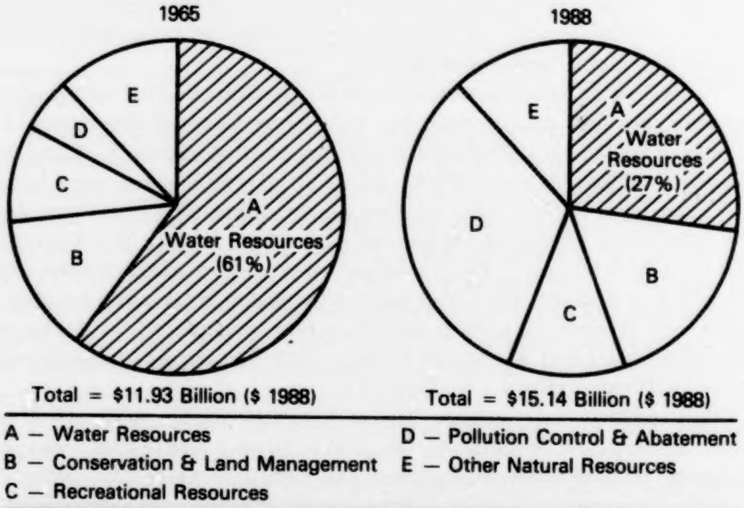


Figure 1b. Total Federal Spending for Natural Resources and the Environment.



Source: Office of Management and Budget, 1988. Historical Tables. Budget of the United States Government FY 1989. U.S. Government Printing Office, Washington D.C.

Developed Water Resource Facilities and Functions

As noted above, water resources facilities function in 13 service areas, but any one type of facility (e.g., dams) may function in more than one service area. The 13 water resources service areas may be briefly described as follows:

■ 1. **Ports.** These provide facilities, including deep channel and associated dredging, for supporting domestic and foreign waterborne commerce. In 1985, the nation's ports handled about 1.18 billion tons of waterborne commerce; this is about 20 percent of worldwide seaborne trade. There are nearly 200 ports in the United States.

■ 2. **Inland Waterways**. Facilities are provided for transportation of goods to ports on inland waterways and to coastal ports for export. The nation's inland waterways handled over 600 million tons of cargo in 1985. There are over 12,000 miles of commercially navigable inland waterways in the United States with over 200 locks and dams. Investments (public and private) in the system are estimated to be nearly $60 billion.

■ 3. **Flood Control.** This service addresses the nation's most costly natural disaster by employing a variety of measures, both structural and non-structural, to abate, reduce and protect against flood damages including loss of life. In addition, there are damage compensation programs to provide insurance and disaster relief. The non-structural and compensation approaches are used to reduce infrastructure needs. The national investment in just structural flood control measures is in excess of $13 billion.

■ 4. **Urban Drainage**. Like flood control features, urban drainage structures remove excess water, but via different and smaller scaled features and before stormwaters reach defined water courses. The investment in the existing urban stormwater infrastructure is tremendous, in excess of $40 billion by 1973.

■ 5. **Dams and Dam Safety**. Dams provide means for controlling water for a variety of purposes. Competing needs for present and future purposes and possibly changing conditions can impact on public safety. Recognizing the potential for catastrophic economic and human losses relative to the 3000 federal and more than 80,000 non-federal dams is a functional water resources service.

■ 6. **Shoreline Protection**. Innumerable structural and non-structural shoreline protection features are in place on portions of the nation's coastlines primarily to protect businesses, homes, land and lives but also to prevent the loss of recreational and environmental values of shoreline areas. An estimated 24 percent of the nation's 85,240 shoreline miles are considered to be sig-

$1.1 billion cumulative expenditure allocated to flood control since Reclamation's first specific allocation of funds for that purpose in 1926.

Nearly 18,500 communities fall under the federal flood insurance programs administered by the Federal Flood Insurance Agency (FIA). In 1985, a particularly bad flood year, FIA paid out $466 million in claims to 51,600 homeowners and businesses. The residual average annual flood damages of $3 billion are the result of urbanization and continuous encroachment onto the floodplains and the fact that the hydraulic and hydrologic attributes of watersheds have been altered by all types of development.

Table 3 shows a downward trend in total federal budget obligations for flood control. Federal spending for the investment and planning of new flood control structures peaked in the mid-1960's and again in the 1970's. Since then, funding for construction of new facilities has decreased. The amount obligated for operation and maintenance of assets currently in use has increased since 1975, however, reflecting an aging infrastructure. Federal budget obligations for technical services, including research, general investigations, weather and storm forecasting, river basin studies and stream gaging have remained stable over the last decade. Budget allocations for emergency services, consisting of emergency protection and preparedness, emergency services and emergency rehabilitation of structures have shown a steady decline since 1975. However, the decline in federal obligations also reflects other factors, including greater non-federal financing and a trend towards non-structural measures such as floodplain management.

Table 3. Estimated federal budget obligations for flood control, by agency.

AGENCY	1975	1980	1985	1987
Corps of Engineers	1,566.8	1,306.3	1,084.5	1,104.9
Soil Conservation Service	321.3	247.5	194.6	160.4
Tennessee Valley Authority	96.4	92.4	50.0	37.1
Bureau of Reclamation	4.2	12.4	32.2	32.2
Federal Emergency Management Agency	28.3	257.3	181.1	161.0
National Oceanic and Atomospheric Administration	51.8	41.3	62.8	71.4
Other Federal Agencies	45.6	12.5	0.0	0.0
Total	2,114.4	1,969.7	1,605.2	1,567.0

Source: U.S. Army Engineers Institute for Water Resources, from Budget of the U.S. Government: Appendix, various years.

Dams and Levees

As of 1981, over 55,000 dams had been constructed in the U.S. for a variety of purposes, including water supply, hydropower, irrigation and navigation. Of these, 11,000 dams were built primarily for flood control. Many of these are small, non-federal dams, owned and operated by private or local interests. By 1985, the Soil Conservation Service had assisted local sponsors in the construction of over 7,800 operational dams and 11,300 miles of channel improvements that were either partially or entirely used for flood control, in small, upstream watersheds. In downstream areas, the existing flood control programs include about 900 multi-purpose reservoirs containing over 110.5 million acre-feet of storage space for flood control, 6,000 miles of levees and floodwalls, and over 8,000 miles of channel improvement works. Of this total over 3,400 miles of levees were completed by the Corps of Engineers and another 2,200 miles were authorized and in various stages of construction or preconstruction activity, but only 150 miles of the levees are maintained by the Corps.[51]

The nation's view of how flood losses should be reduced has been changing. The trend is away from encouraging floodplain use and protecting people and property, and towards efforts that emphasize nonstructural measures such as insurance, floodplain management and flood warning and emergency evacuation procedures. Since 1975, there has been an acceleration in flood plain regulation and a slowed growth in the implementation of structural measures. For example, during the 1960's, reservoir capacity for flood storage grew by an average of 6 percent a year, declined to 2 percent a year in the 1970's and has now slowed to growth rate of less than 1 percent per year.[52] In its place, local protection and floodplain management has increased.

Stormwater Drainage

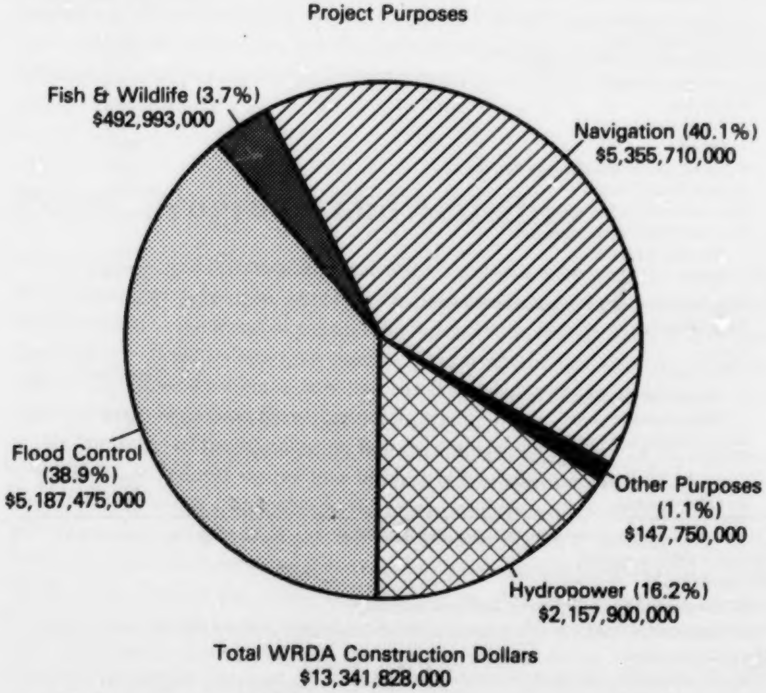
The distinction between flood control and stormwater drainage is important to bear in mind. Generally, flood control measures deal with containing natural stream runoff by attempting to regulate peak flows (reservoirs) or keep floods from overflowing their banks (levees). Drainage problems are inherently tied to the conveyance of excess water that collects on the land. Both types of flooding cause equivalent property damage, although drainage is not life-threatening. Drainage systems are required to collect and convey stormwater runoff for discharge into a waterway. These systems consist of drainage ditches, channels, inlets, storm sewers, collector sewers and detention facilities.

Data on the physical or financial components of urban stormwater drainage systems are limited by the absence of a significant federal mandate in this water resource category.

Most urban drainage system improvements have historically been performed in conjunction with street improvements and development. The American Public Works Association estimated in 1966 that the total capital investment in storm sewers alone was $22 billion in 1965 dollars ($98.6 billion in 1988 dollars).[53] According to Linsley, the total investment in urban stormwater facilities in the United States by 1973 exceeded $40 billion ($114.2 billion in 1988 dollars), an amount greater than the total investment in flood whether there is a federal interest in the proposed undertaking. The feasibility phase, which develops the economic and environmental feasibility of projects in which there is a federal interest, is cost shared equally between the Corps and the local sponsor (except for inland navigation projects) under a formal study cost sharing agreement which defines the budget, study tasks and schedule.

Although the number of projects and studies authorized in WRDA 86 is significant (Figure 5), its policy changes will have more impact. The Act substantially modifies the approaches to the planning and financing of projects which evolved over the last half-century. Revisions in cost sharing requirements, the imposition of ad valorem cargo taxes to maintain harbors, increases in inland waterways fuel taxes to support lock and dam projects, and various other reforms, will result in greater participation by states, ports, waterway interests and local communities in both the financing and designing of water projects.[73]

Figure 5. 1986 WRDA Construction Program.



Source: U.S. Army Engineer Institute for Water Resources, 1988. VISION 21: A Strategic Assessment of the Nation's Water Resource Needs. Unpublished Draft Report. Fort Belvoir, VA.

The effectiveness of the "beneficiary pays" policy is not limited to resolving the respective roles of federal and non-federal interests. It also provides the basis for the program to proceed in an environmentally acceptable manner. It is noteworthy that many environmental organizations supported enactment of Water Resources Development Act of 1986.[74]

Environmental Effectiveness of Policy Reforms

A series of normative assumptions can be used to suggest that the net impact of cost sharing policies on environmental resources will be positive, and indeed the results to date look encouraging:

Cost sharing will result in fewer projects being advanced for authorization as local sponsor willingness to pay or ability to pay will act as a selection constraint. Reduction of the total number of projects authorized for construction should also reduce the cumulative environmental impact caused by all projects that do proceed to construction.[75]

Title X of WRDA 86 deauthorized some 300 projects or elements of projects which would have cost in excess of $11 billion to construct. The bill had other related provisions. Projects authorized in WRDA 86 are deauthorized if not funded within 5 years. Additionally, reports were to be made to Congress, separately, of projects and of studies recommended for deauthorization. The reports of studies were to be fled every year; the first, in September 1987, identified 555 projects, and the second, in 1988, identified 63. Deauthorization is automatic unless Congress acts within 90 days of the filing of the report. and no such actions have yet been taken. The reports on projects are to be filed every two years. Such a report was filed in November 1987 and it identified 359 projects for deauthorization. For such projects, Congress has 30 months to take action.

The 1986 Water Resources Development Act established annual obligation ceilings for the Corps' "Construction, General" appropriations account. This ceiling was $1.4 billion for fiscal year 1987, and is to rise to $1.8 billion in fiscal year 1991.

Cost sharing will result in smaller projects as local sponsors request downsized project features to accommodate available budgets or choose to phase project construction in order that the initial benefit stream may be evaluated prior to committing additional resources. As a result of scaling back and phasing of projects, the federal government is spending $400 million less than authorized at Norfolk Harbor; $100 million less at New Orleans; $113 million less at Mobile; $69 million less at Baltimore and $22 million less at Little Dell. It is anticipated that smaller projects will result in reduced environmental impacts as they will tend to consume less land, generate reduced volumes of dredge spoil, fewer structural relocations, etc.

in 1987; the value of recreation on project lands totaled about $623 million for the same period. The Fish and Wildlife Service, which manages 90 million acres for habitat protection, fish hatcheries and wildlife management also provides for wildlife-related recreation activities.

To assist visitors at projects, the Corps of Engineers employees a total of 1,558 rangers. TVA has 250 land use specialists which serve a similar purpose. The BuRec has these responsibilities assigned to local interests, or other federal agencies such as the National Park Service.

Wastewater Treatment

The wastewater treatment service area is a subject separate from the developed surface water resources being emphasized in this chapter, and will not be elaborated on here. It is, though, one of the largest parts of the developed water resources infrastructure. From 1978 to 1986, the total value of wastewater facilities rose 25 percent, from $110 billion to $138 billion as a consequence of the Clean Water Act. This growth included increased federal grant funds for capital outlays for new plant. The operational costs of such facilities are borne primarily by local interests. The method of financing the entire wastewater treatment service area is changing towards an increased reliance on user fees, thus paralleling changes in the flood control and navigation service areas.

Policy, Programs and Activities

At the beginning of this decade, there was no consensus on what the respective water resources development roles of various levels of government should be. Some wanted to continue or expand the federal role, others wanted to reduce dependence on the federal government. This disagreement, evolving since the 1960's, had yielded a stalemate within the federal government with respect to national water resources development policy.

At the heart of the impasse on federal water policy were the classic confrontations of federal versus non-federal responsibilities and development versus preservation. Interestingly, the same policy principle served to provide the basis for compromise on both dichotomies. That principle is that beneficiaries of federal programs must pay a reasonable portion of the costs of the programs. In the water resource arena, this principle takes various forms for various types of activities; sharing of actual construction costs, user fees and trust fund contributions through marine fuel surcharges or through the value of cargo transported.

With the passage of WRDA 86, cost sharing and local cooperation agreements with non-federal project sponsors became required for all new water resources development projects. The exception has been improvements to the inland waterway navigation system for which the non-federal share is provided through the Inland Waterways Trust Fund. (See Table 6.) WRDA 86 also brought cost sharing to the study process, which is now conducted in two-phases. The initial reconnaissance phase is generally fully funded by the federal government and is to be completed in 12 to 18 months. It determines

Table 6. Cost sharing requirements.

FEDERAL AGENCY	NON-FEDERAL SHARE
Feasibility Studies	
Inland Waterway System	0
All Other Purposes	50%
Construction	
Harbors	
Depths 20 ft or less	Min. 20%
Depths 21 ft to 45 ft	Min. 35%
Depths over 45 ft	Min. 60%
Inland Waterway Systems	50%[1]
Flood Control[2]	
Structural	Min. 25%; max. 50%
Nonstructural	25%
Hydroelectric Power	100%
Municipal and Industrial Water	100%
Agricultural Water[2]	35%
Recreation	
Navigation	50%
Other	50%[3]
Hurricane and Storm Damage Reduction	35%
Aquatic Plant Control	50%
Fish and Wildlife Mitigation	[4]
Fish and Wildlife Enhancement	
National Benefits	0%
Other	25%
Operation, Maintenance, Replacement and Rehabilitation	
Harbors	
In General	Up to 40%[5]
Deep Draft Depths over 45 ft	50%[6]
Recreational Harbors	100%
Inland Waterway System	0
Fish and Wildlife Mitigation	[7]
Fish and Wildlife Enhancement	25%
All Other Purposes	100%

[1] Where authorized; non-federal share to be paid from Inland Waterways Trust Fund (fuel taxes paid by users).

[2] Subject to ability-to-pay test.

[3] Of separable costs.

[4] Costs allocated among project purposes and shared accordingly.

[5] Non-federal share of O&M to be from Harbor Maintenance Trust Fund (ad valorem fee on goods transported).

[6] Of costs over 45 feet.

[7] Costs allocated among project purposes and shared accordingly.

While the data on cost-shared projects regarding explicit benefits is neither complete nor conclusive, based on an analysis of cost-shared new starts it appears that sponsors have tended to recommend phasing of deep draft navigation projects with reduced dredge depth or, in specific cases reduced channel width. At Baltimore Harbor, for example, the originally authorized project called for deepening the existing channel to 50 feet and widening it to 1,000 feet. The scheduled project now has the same 50 foot channel but a reduced channel width of about 800 feet. Phasing of deep draft navigation projects will probably result in reduced net environmental impact as dredge spoil volumes are accordingly reduced. This reduction will have the greatest impact for those projects that must dispose of dredged material in contained sites as the opportunity cost of site replacement imposes both additional construction and environmental costs.

While the data on phased or downsized flood control projects is not sufficiently conclusive to project the magnitude of environmental impact decrements associated with reduced project size, there exists some evidence that reducing reservoir storage capacity and careful routing of diversion channels has led to decreases in required mitigation measures. One example is at Little Dell Lake, Utah, where the authorized project called for construction of a dam 253 feet high, creating a lake with a storage capacity of 30,000 acre-feet. As constructed, the dam will now be 226 feet high creating a smaller sized lake of 20,500 acre-feet of storage capacity. The reduction in associated riparian habitat losses is obvious.

The participation of local sponsors in the design process will assure that environmental concerns are fully addressed and carefully evaluated. Because sponsor consent must be achieved before a Local Cooperation Agreement can be achieved, and ultimately a project completed, local environmental perspectives will be afforded the full attention of the federal partner. Projects, or project features, that are perceived to represent unacceptable environmental risks will either be eliminated from the selection process or modified to reduce the environmental impact to a level that allows for sponsor/community support of the project.

One of the refreshing aspects of the new procedures is that partnership arrangements with non-federal sponsors have exceeded expectations. Despite the fact that sponsors are paying more for these projects, they have shown that they are willing to plan and design projects that are economically efficient and environmentally sound. They have equal status in planning and decision making. Non-federal sponsors at the state and local levels support these changes both in Congress and at the negotiation of local cooperation agreements (LCAs). At the end of 1988, of the 131 new projects requiring LCAs, 82 had been negotiated and signed, while the remainder are under active negotiation.[76] Corps project managers have overwhelmingly reported that coordination with local sponsors, both on policy and technical matters, has increased and improved with cost-sharing. This suggests that sponsor concerns regarding project environmental features enjoy a high level of administrative attention.

Environmental Provisions of WRDA 86

WRDA 86, P.L. 99-662, in addition to setting forth cost sharing provisions for non-federal sponsors of water resource projects, enacted a variety of measures directed at evaluation, restoration, protection or enhancement of the natural environment. Individual measures contained in the Act include (but are not limited to) the creation of an Office of Environmental Policy in the Civil Works Directorate of the Office of the Chief of Engineers (Sec. 924), provision for modification of projects constructed prior to passage of the Act to improve environmental quality (Sec. 1135), authorization of an Environmental Protection and Mitigation Fund (Sec. 908), the requirement that mitigation plans be submitted along with a proposed project, and for the mitigation to be done before or concurrent with project construction (Sec. 906), and authorization of a number of studies and/or projects that either directly (Study of Corps Capability to Conserve Fish and Wildlife, Sec. 704) or indirectly address environmental resource concerns.

Fiscal Year 1989 Budget

The Presidential Budget request for fiscal year 1989 was the first to implement the provisions of WRDA 86, and included the following environmental measures:

- **Chesapeake Bay Time Variable Model.** The Corps, U.S. EPA, state and local interests are developing a variable three dimensional hydrodynamic and water quality model of the Chesapeake Bay. When complete, this model will allow resource managers to test alternative management strategies to determine which measures should be applied, their effectiveness and results. The funds requested for Fiscal Year 1989 will be used to complete assembly and verification of the hydrodynamic model and to conduct hydrodynamic simulations for the water quality model simulations. A draft hydrodynamic user's guide will also be prepared.

- **Fisheries Habitat Restoration and Creation Pilot Studies.** The Corps, in cooperation with the National Marine Fisheries Service is conducting two pilot studies involving the use of dredged materials for the creation or enhancement of fisheries habitat. In Galveston Bay, Texas, two disposal areas at Chocolate Bay and Pelican Spit will be modified by the planting of saltmarsh cordgrass (*Spartina alterniflora*). This work is designed to demonstrate the success of establishing productive salt marshes on dredged material. In North Carolina, three diked disposal areas will me modified to include shallow, sloped intertidal areas and associated zones of marsh grass and subtidal seagrasses. These areas will support important coastal species such as shrimp, menhaden, mullet, red drum, bluefish and blue crabs.

■ **The Lower Snake River Fish and Wildlife Compensation Program.** This project will provide compensation for the fish and wildlife impacts caused by the construction and operation of the four Lower Snake River dam projects in the states of Washington and Idaho. The Compensation Program consists of a number of Chinook and Steelhead hatcheries that will provide 27,000,000 juvenile salmon and steelhead annually. These fish will be released in streams for migration to the Pacific Ocean resulting in over 4 millions pounds of commercial fish and 689,000 additional angler days of sport fishing. Funds appropriated in Fiscal Year 1989 will be used to continue fish hatchery land acquisition and hatchery construction, and to produce mitigation for game bird habitat.

■ **The Atchafalaya Basin Floodway System.** The Corps has developed a plan for the management and preservation of the water and related land resources of this Louisiana River basin. The plan includes provisions for reductions of siltation, improvement of water quality and possible improvements of the area for commercial and sport fishing. Provision of additional public access and several campgrounds, boat launching ramps and other recreational facilities are also included to allow public enjoyment of the area's unique environmental values. The Fiscal Year 1989 funds will be utilized to continue acquisition of the necessary real estate interests for flood control and development of environmental and public access project features.

■ **Cooper Lake and Channels.** This project in Texas includes wildlife mitigation measures estimated to cost over 21 million dollars. The Fiscal Year 1989 budget request included funds to initiate mitigation development at the Cooper Lake area. These measures were authorized by WRDA 86 and include fee acquisition of land, and the development and management of approximately 25,000 additional acres for wildlife and habitat improvement.

■ **Mississippi and Louisiana Estuarine Areas.** The Mississippi and Louisiana Estuarine areas are located in southeastern Louisiana and southern Mississippi. The estuaries are important to oyster production, as breeding areas for shrimp and food fishes, and as food production areas for fur-bearing animals and migratory waterfowl. The Corps is currently studying proposals to control salinity and supplement nutrients in this area by diverting freshwater from the Mississippi River to coastal bays and marshes. Benefits will include restoration of former ecological conditions by controlling salinity and supplementing nutrients. Fiscal Year 1989 funds will be used to complete design of a monitoring program, real estate planning and plans and specifications for the first item of construction.

Fiscal Year 1990 Budget: Concurrent Mitigation

Section 906 of WRDA requires that reports for authorization of water resources projects must contain a recommendation and plan to mitigate fish and wildlife losses, or a determination that the project wil have negligible effect on fish and wildlife. It also specifies that any action to mitigate fish and wildlife losses caused by a project should be undertaken prior to, or concurrent with, construction of the project. The first application of this directive will come with the construction new starts requested in the Fiscal Year 1990 budget. There are eleven such new starts; the following two illustrate the consequences of a concurrent and proportional spending policy for environmental features, including mitigation:

- **Santa Ana River Mainstem, California.** This flood control program has a total estimated cost of $1,382 million; the total mitigation costs are presently unknown (particularly for endangered species and cultural resources) but likely to be in the range of 1.5 percent to 2 percent of the total cost. The Fiscal Year 1990 request for funds totals $20 million of which $5 million is for lands to enhance endangered species. In this instance the expenditures would well precede construction of the project element which cause the environmental impact.

- **Sims Bayou and Houston, Texas.** The total cost of the flood control project is $124 million. Environmental amenities include revegation to mitigate riparian habitat losses, and recreational developments which include biking and hiking trails and picnic areas. Such environmental elements will costs about 1.8 percent of the project total. The Fiscal Year 1990 budget request is for $4 million of which $50,000 or 1.2 percent will be to commerce the recreation development.

Through the reforms of WRDA 86 and the Army Corps of Engineers' demonstrated commitment to balanced resource development and conservation, a blueprint has been developed which can lead this nation into the twenty-first century with a water resources program to meet the nation's development needs economically, in an environmentally sound manner. For the first time, this will be done in full partnership with states and local government and the private sector who all share in the responsibility.

Bureau of Reclamation Mission Refined

The Bureau of Reclamation's original mission to construct large, federally financed irrigation projects soon will be virtually completed. With this in mind, in October 1987, Reclamation announced a redirection of the agency's mission, shifting the emphasis from water resources development to water resources management.[77] Reclamation has drafted a number of new initiatives for 1988-89 that target the environment. Fisheries restoration and enhancement are underway in California and the Pacific Northwest, where the Bureau is also studying wildfowl requirements along the Pacific Flyway. An Irrigation Drainage Task Force evaluating irrigation return flow water quality in the 17 Western states to identify corrective actions needed. The Bureau's unique Colorado River Water Quality Improvement Program is reducing salinity in the Colorado River. This approach is consistent with the nation's changing priorities for high quality water and the accompanying necessity for more effective, efficient conservation and management of its water resources. In order to stay current with the nation's needs and accomplish its changing mission, Reclamation has identified several new initiatives.[78]

System Optimization and Joint Use

Considerable opportunity exists to increase output from already constructed Reclamation facilities through operational, management and institutional changes or physical improvements. Emphasis will be placed on more efficient use of existing facilities instead of building new ones. There are also opportunities to achieve benefits by integrating or jointly operating Reclamation facilities with other public or private facilities. New policies and practices will encourage water conservation while simplifying water transfers and exchanges.

■ **Operations and Maintenance of Facilities.** Operation and maintenance of facilities will remain one of Reclamation's most important priorities in order to achieve reliable delivery systems, improve system efficiencies, conserve water, enhanced water quality, extended useful project life and reduced operation and maintenance costs. Federal investments already made will be protected, and maintenance of existing facilities will have priority over construction of new ones. In addition, new, state-of-the-art technology will be applied to avoid degradation of the environment and fish and wildlife values.

■ **Construction.** Three major program components now receive approximately 70 percent of Reclamation's construction dollars: The Central Arizona Project, Central Utah Project and the Safety of Dams Program. However, between 1970 and 1985 about two dozen construction starts were authorized and most have been built. Reclamation's construction budgets have shown a gradual and consistent increase for fiscal years 1985 through 1989. The FY 1989 budget continues Reclamation's practice to maintain optimum funding of those projects well underway and nearing completion in order to make project benefits available sooner. By the mid-1990's, Reclamation's major construction projects are expected to be substantially complete. In the future, the federal budget restraints will discourage continued support for new capital-intensive water resource program, and construction will be primarily in support of resources management objectives.

■ **Non-Federal System Operation.** Where legal and institutional barriers can be removed, opportunities exist to transfer the operation of some larger Reclamation systems from the federal government to user entities. Examples include:

- In California, Central Valley Project (CVP) and State Water Project (SWP) operations are becoming more closely integrated with CVP facilities and SWP facilities now both managed by staff located in Sacramento.
- Reclamation is negotiating a cooperative agreement with the Tehama-Colusa Canal Authority for operation and maintenance of the Tehama-Colusa and Corning Canals. In 1995, new water service contracts will be negotiated requiring the water contractors to fund operation and maintenance themselves.
- Reclamation is continuing its longstanding policy of transferring facilities to qualified local water user organizations for operation and maintenance, with approximately 360 projects transferred to date.

■ **Research.** Research remains a viable and vital program within Reclamation, particularly research proposals directed toward the agency's new mission. For example, a pilot program is underway to test an innovative method of lining earthen canals, without draining them, stop leakage and to conserve water. If feasible, 66 miles of unlined sections of operating canals in California may be lined, reducing seepage losses by an estimated 100,000 acre-feet of water each year.

A recent research initiative is the area of global climatic change and the impact on water supplies and water use. Other Reclamation research studies focus on water augmentation through weather modification, water quality and ecology, dam safety, advanced engineering evaluations of materials and technologies, and water conservation concepts.

■ **Land Resources Management.** Resource protection and quality recreation opportunities are important goals of Reclamation land management. In 1987, Reclamation projects attracted over 53 million visitors who participated in such activities as boating, sailing, hunting, fishing, camping, white water rafting, hiking, biking, and sightseeing.

Reclamation is developing enhanced opportunities for public recreational use of project lands and waters through a new land management planning process that will serve as a blueprint for future development and management activities on project lands. Public involvement and the development of cooperative management agreements including larger levels of local cost sharing will play a major part in land management planning.

■ **General Investigations.** The fiscal year 1989 budget reflects Reclamation's reorientation, with proposals for 11 innovative planning studies that focus on nonstructural, management, water efficiency, and conservation solutions to the West's water needs. Approximately $12 million will be used to plan cost-effective ways to increase efficiency at existing projects, protect groundwater quality and supplies, and study resource management measures that do not involve construction of major facilities.

USDA Water Resources Activities

The programs of the United States Department of Agriculture and its Soil Conservation Service provide clear examples of how seemingly unrelated legislation can have profound impacts on resource conservation practices generally, and water resources management goals, in particular.[79] The Food Security Act of 1985 (Public Law 99-198), was designed to strengthen the conservation practices of farmers who participate in USDA commodity programs. The objectives of the Act are to reduce erosion, sustain the productive capability of farm land, reduce sedimentation, improve water quality, improve fish and wildlife habitat, reduce crop surpluses, and provide needed support for farmers. Under the "sodbuster" provisions of the Act, highly erodible land that is being brought into production of an annually billed crop after December 23, 1985, must be protected with an applied conservation system immediately. The "swampbuster" provisions specify that wetlands cannot be converted for production of annually billed crops after December 23, 1985.

In addition, the Conservation Reserve Program (CRP) encourages farmers to remove highly erodible cropland from crop production and plant it in grass or trees through 10-year contracts with the USDA. The CRP has the potential of removing from cultivation up to 45 million acres of highly erodible land. CRP is administered by USDA's Agricultural Stabilization and Conservation Service (ASCS), with assistance from other USDA agencies including the SCS, the Extension Service, and the Forest Service.

USDA, through seven sign-ups has accepted bids on 28,130,290 acres of cropland that will be converted to permanent cover. Of this, 1.7 million acres will be planted to trees. Also, over 29,000 acres of filter strips along more than 2,300 miles of stream banks will be established. The highly erodible land provisions impact about one-third of the nation's cropland (143,000,000 acres) and 70-75 percent of the nation's farmers (about 1.2 million conservation plans are needed). This will result in significant erosion reduction on highly erodible land. The level of erosion reduction will vary from 46 to 75 percent depending upon the level of treatment and the present erosion rate. Total erosion, as a proportion of all the cultivated land is expected to be reduced by 25 percent. Wetland protection provisions are designed to discourage the conversion of the remaining 70 million acres of agricultural wetlands.

These programs promise to be among the most effective in reducing sediment loading of streams along with a consequent reduction in agricultural pollutants. The SCS was historically concerned with the physical linkages between the farm practices, soil erosion and flooding. Their perspective was on watershed management and balancing of practices and uses of increased water yield while reducing flood damages; and to reduce soil erosion as a prelude to improving fish and wildlife habitat. After an intensive period of combining farm management practices with development of watershed control structures (detention ponds, small reservoirs, farm ponds, etc.), the SCS is redirecting its programs consonant with current national concerns. These include water quality, safe and adequate rural water supply for disadvantaged rural communities, wetland enhancement, fish and wildlife habitat improvement, water conservation, sedimentation reduction, and other natural resource protection needs.

Research and Development

Research and development studies and investigations of many types, and involving many disciplines, are being conducted throughout the agencies and departments of the federal government. The Army Corps of Engineers, Bureau of Reclamation, Tennessee Valley Authority, and Bonneville Power Administration have many areas of mutual interest which require research and engineering investigations. The planning, design, construction, and operation of dams, hydraulic structures, and power generation and transmission facilities, present many problems. Some of these require extensive and complex studies to aid in making engineering, economic, and environmental decisions. Free interchange of technical information among the agencies has taken place for many years on an informal person-to-person basis. However, such exchanges usually give little information on the overall picture. To offset this, formal conferences have been held to provide overall information and coordination of the agencies' research programs. The conferences have been held on a biennial basis since 1960. In addition to the four water resource member agencies, representatives of the U.S. Bureau of Mines, the Department of Energy, the Federal Energy Regulatory Commission, and the U.S. Geological Survey have participated as observers at the Conferences.[80]

The Corps of Engineers has one of the premier research and development capabilities in the world. It was begun in 1929 after a disastrous flood on the Mississippi River. It supported the development and management of protection and use strategies for rivers, estuaries and other water resources. Since that time, the scope of the R&D activities has broadened to keep pace with the increased use of coastal and other water resources. Added emphasis to the R&D mission has been the growing public concern for protection of our natural resources and the environment.

The purpose of the R&D program is to gain a better understanding of the physical processes involved in the interaction of water and shorelines, to develop ways to predict natural occurrences and how man-made actions will interact with those occurrences, and to develop physical and management techniques which will protect the resource while it is being utilized for private and public purposes. The program addresses the present civil works problems as well as problems foreseen in providing for the needs of the future. Future needs include those arising from increased private and public demand on the natural resources, and the need to maintain and enhance protective measures and management techniques already in place. Water resources R&D is focused in three primary areas: coastal engineering, flood control and navigation, and water resources planning. Several programs within the latter area serve environmental needs: environmental impact, wetlands, long-range effects of dredging, and planning methodologies.[81]

■ **The Dredged Material Research Program (DMRP)** is a prime example which provided the major technical base on which regulation of the disposal of dredged material is based. The Corps initiated the DMRP in 1973 and successfully completed the program in 1978 at a cost approaching $33 million.[82]

■ **The Corps of Engineers Waterways Experiment Station, the U.S. Fish and Wildlife Service, and the Environmental Protection Agency** are all working together to provide better understanding of wetland ecosystems and means of preserving and enhancing them in connection with water resource projects. During the Reagan Administration, the Corps alone has spent $7.2 million on bio-accumulation and other long-range effects of dredging, $5.1 million on wetland research efforts, some $16.4 million for water quality operations, and $14.4 million on environmental impact research. The Bureau has spent about $6 million on environmental research for reservoir and canal management, and $0.5 million on habitat management research. These investments are expected to pay dividends as the water resources programs move into the 21st Century.

■ **The Construction Productivity Advancement Research Program (CPAR)** is a cost-shared partnership between the U.S. Army Corps of Engineers, the U.S. construction industry and other interested parties. Its goal is to facilitate the research, development and application of advanced technology for the purpose of assisting the U.S. construction industry in increasing its productivity and in improving its competitive position, domestically and abroad. Because of the extent of construction performed by the Corps, significant productivity advances are anticipated in the water resources development field.

American industry has responded enthusiastically to the program and supports it in concept. Industry has come forward with cost sharing proposals for innovations and improvements in construction industry practice, technique and materials. Industry feels that this is an exciting new approach to solving the greatest problem in the construction industry—low productivity. Over fifty proposals are under negotiation with potential cost sharing partners. Work will be initiated on the best of these proposals in Fiscal Year 1989. To fund the CPAR program, $3.0 million is being reprogrammed in Fiscal Year 1989 and $4.0 million has been requested for Fiscal Year 1990.[83]

Future Issues to be Resolved

Notwithstanding the substantial progress made in recent years to achieve a program which provides for water resource development needs while maintaining and enhancing environmental quality, some old issues remain to be resolved and some evolving issues will require close attention.

Wetlands

Although an entire chapter of the CEQ's 17th Annual Report[84] was devoted to wetlands, their relationship to federal water resources development activities is important to amplify here.

Wetland conservation and regulation have been important topics during the past twenty years. Major accomplishments have been made recently in working towards resolution of several of the most thorny issues. For example, the issue of wetland definition has been resolved. A wetlands delineation manual has been field tested and agreed to by all federal agencies with responsibility for wetland management activity. Further, the Environmental Protection Agency and the Army Corps of Engineers have developed memoranda of agreement on determining geographic jurisdiction, exemptions and regulatory enforcement under Section 404 of the Clean Water Act. However, much remains to be done.

The status of the nation's remaining wetlands is a current focus of water related environmental policy. In 1987, a nationally convened forum of 20 representatives of a broad cross-section of governmental and private sector interests met to consider the problem of disappearing wetlands. Their final report, published in November 1988, and titled "Protecting America's Wetlands: An Action Agenda,"[85] is a compilation of some 100 recommendations to accomplish "no overall net loss" of the remaining wetland base. The forum recommended this as an interim goal, with a long-term goal of increasing the quantity and quality of the wetland base. To achieve this goal would require extensive revisions in the way federal, state, and local agencies have been doing business with regard to wetlands. It will also require the support and input of the private sector.

The forum also recognized that in order to contribute meaningfully to the long-term goal of increasing the quantity and quality of the nation's wetland base, the restoration and creation of wetlands will be necessary. The forum recommended that the Congress establish wetlands restoration and creation as part of the mission of the Corps of Engineers, the Bureau of Reclamation, the Soil Conservation Service, the Federal Highway Administration, the Tennessee Valley Authority, and other appropriate federal agencies. The problem facing the water resources development agencies, whether state or federal government, is how to construct water projects to avoid wetland areas. When wetlands cannot be avoided, the problem is to maintain balance with the environmental amenities provided by the affected wetland. There are various ways of addressing wetland losses. Acquisition of additional, separable wetlands is the common response of the Corps, to the extent that such acquisition can be justified under the Principles and Guidelines. In some instances, creation of new wetlands (e.g., placement and planting of dredged or excavated material, or "shaving" down an upland site, etc.) or the restoration of a previously degraded wetland area is recommended.

The creation of wetlands is a relatively new technique being pursued by a number of water resources development agencies in cooperation with the natural resources agencies. The Waterways Experiment Station, one of the Corps of Engineers laboratories, has been conducting research for over a decade on the beneficial uses of dredged material for the creation of wetlands. About 10,000 acres of wetlands, of various kinds, have been developed under these experimental efforts around the country.

Recently, the Corps of Engineers and the National Marine Fisheries Service completed a cooperative fisheries habitat restoration and creation pilot study.[86] This three-year study, completed in October 1988, looked at, among other options, ways that dredged materials from maintenance dredging could be used to create wetlands habitat to benefit fishery resources. The results of this pilot study are being examined to determine whether or not an ongoing, national program between the Corps and NMFS would be effective. Creation of wetlands is physically possible, as shown by the Corps research programs and the work of a number of private consulting firms in the business. There is an issue to be resolved, however, in whether and to what extent created wetlands function as well as natural ones. Studies are now underway to determine this.

Loss of wetlands as a consequence of private development activities has contributed significantly to the country's diminishing wetlands base. It is estimated that about 15 percent of the annual loss of wetlands can be attributed to private development which is regulated under Section 404 of the Clean Water Act. Much of the remaining wetlands loss is from agricultural conversions of wetlands outside federal jurisdiction. The Office of Technology Assessment estimated that of the wetlands that were converted under permit each year, only ten percent of the loss was mitigated.[87] One issue to be resolved is the extent to which a regulatory program is appropriate for effective prevention of these losses and, where unavoidable, the replacement of the lost wetlands.

Many other issues remain to be resolved. For example, during more than a decade since passage of the Clean Water Act Amendments of 1977, few states have come forward to assume section 404 authority to regulate development activities in their wetland areas. The relationship between water resources development and wetlands is clear indeed. Exactly how that relationship will work both environmentally and institutionally will be one of the challenges of the 1990's.

Mitigation

Mitigation requirements and considerations are set forth in several federal laws and statutes, and in certain federal regulations. Principally, these include, the:

1. Fish and Wildlife Coordination Act (FWCA) of 1958[88]
2. Clean Water Act; EPA 404(b)(1) Guidelines[89]
3. Water Resources Development Act of 1986[90]
4. The National Environmental Policy Act (NEPA); CEQ Implementing Regulation[91]

The Endangered Species Act is not listed here because the Act does not address mitigation, per se. The Act does direct the Secretaries of Interior and Commerce to provide reasonable and prudent alternatives for those proposed actions that are likely to jeopardize the continued existence of endangered and threatened species, and their critical habitat. They are also directed to provide conservation recommendations to protect the species.

There are three different substantive requirements as to when federal water resources agency projects should provide mitigation for adverse impacts on the environment. For projects involving discharges of dredged or fill material in the waters of the United States, the EPA's 404(b)(1) guidelines, 40 CFR Part 230, establish the mitigation standards for adverse impacts on the aquatic environment. Part 230.10(d) of the 404(b)(1) guidelines prohibits the discharge of dredged of fill material "unless appropriate and practicable steps have been taken which will minimize potential adverse impacts of the discharge on the aquatic ecosystem." This "appropriate and practicable" standard applies to the entire aquatic environment, which includes other impacts as well as impacts on fish and wildlife.

In addition, there are two substantive requirements for mitigation for losses to fish and wildlife. They are set forth in the Fish and Wildlife Coordination Act (FWCA), 16 U.S.C. 661 et seq., and the Water Resources Development Act of 1986, P.L. 99-662. Section 662(b) of the FWCA requires that reports submitted to Congress for the authorization of water projects include "such justifiable means and measures" of mitigation "to obtain maximum overall project benefits." Section 906(d) of P.L. 99-662 establishes another standard for Army Corps of Engineers projects commenced after the date of its enactment. It requires that reports submitted to Congress for authorization of a project shall contain:

(1) a recommendation with a specific plan to mitigate fish and wildlife losses created by such project, or

(2) a determination by the Secretary that such project will have negligible adverse impacts on fish and wildlife.

This provision requires development of a mitigation plan which will mitigate for all but "negligible" adverse impacts. Section 906(g) states:

> (g) The provisions of the subsections (a), (b), and (d) shall be deemed to supplement the responsibility and authority of the Secretary [of the Army] pursuant to the Fish and Wildlife Coordination Act, and nothing in this section is intended to affect that Act.

CEQ/NEPA Guidelines[92] define the type of mitigation that should be considered.

(1) Avoiding the impact altogether by not taking a certain action or part of an action.

(2) Minimizing impacts by limiting the degree or magnitude of the action and its implementation.

(3) Rectifying the impact by repairing, rehabilitating, or restoring the affected environment.

(4) Reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action.

(5) Compensating for the impact by replacing or providing substitute resources or environments.

Mitigation, particularly that involving compensation of unavoidable, significant impacts, is determined largely based on the type of impact analyses performed. Impacted resources can, and often do have values that can be expressed in both monetary and non-monetary terms. For example, a particular area may produce opportunities to hunt and fish. If a project impacts on these uses, the losses can be expressed in monetary terms, i.e., user day, hunter days, fishermen days, etc. Such analyses are fairly simple since values are expressed in a single parameter — dollars.

However, many environmental values cannot be expressed in monetary terms. For example, it is very difficult to place a monetary value on a historic monument, on an archaeological site, or habitat for nongame wildlife. For these reasons, a wide range of assessment methodologies have been developed to address their many values. Since wildlife is dependent on the type and quality of habitat available to them, several habitat based methodologies have been developed. Independent and cooperative research and field testing of emerging methodologies can help to determine which are the most sound and applicable to water resources planning. An example of cooperative efforts is joint research and field testing of the U.S. Fish and Wildlife Service and the Army Corps of Engineers Habitat Evaluation Procedures (HEP).[93] An example of an independent effort in this same field is the Habitat Evaluation System (HES) developed by the Corps Lower Mississippi Valley Division.[94] Both methods are commonly used and have added considerably to the state of the art for evaluating fish and wildlife habitat and associated mitigation measures. Additionally, the Habitat Management Evaluation Method (HMEM) was developed by the Bureau of Reclamation, in conjunction with the Fish and Wildlife Service, for need in the Garrison and Central Arizona projects, and is currently undergoing field tests by the Corps of Engineers.[95]

Many issues remain surrounding the need for and degree and type of mitigation. Should one-for-one mitigation be required regardless of cost; should habitats be replaced in kind or is an alternative substitution acceptable; or should mitigation be adopted to restore and enhance the environment to make up for historical losses? These are just a few of the questions which must be addressed in the coming years.

Drought

The drought of 1988 was one of the worst on record for the central United States and adversely affected many other areas. In an economy as large as that of the United States, sectors most directly affected by the drought account for a relatively small share of the aggregate output. Therefore, while the drought had significant negative effects on important sectors of the economy, the impact on aggregate economic activity was relatively small.[96]

The drought and searing heat took their toll on grain and soybean harvests. Indicative of the drought's severity, the 1988 average corn yield was 31 percent below trend, the largest drop since the mid-1930's, and the soybean yield was 17 percent below trend, the largest decline over the past 60 years.

The primary inland waterways were greatly impaired by the drought. Following an unprecedented number of groundings on the lower reaches of the Mississippi River and lower reaches of the Ohio River, the Corps of Engineers and the Coast Guard in late June imposed restrictions on the draft and number of barges per tow on these river segments. With increased dredging by the Corps of Engineers, increased aids to navigation by the Coast Guard, and reduced barge tow sizes and drafts, navigation was able to continue. However, these restrictions reduced the volume moved by a single tow as much as 50 percent. Concerns that movement of farm products would be disrupted did not materialize. Declines in July and August, a seasonally slow time for farm product shipments, were significant, but 1988 shipments still exceeded 1986 levels.

The drought also affected nesting and breeding habitat of numerous species of waterfowl and spawning sites and nurseries of many sport and commercial fish species. Island and sandbar nesting habitat of the endangered Least Terns and Piping Plovers along and Missouri River was protected by the controlled flow releases at Corps of Engineers dams. The controlled releases allowed the birds to complete their nesting cycles.

In the early stages of the 1988 drought, a high priority was assistance to livestock producers. As the drought worsened and production losses became more evident, attention focused on financial aid to crop producers under current federal crop insurance, emergency loans, and new legislation. The Disaster Assistance Act of 1988 will provide about $3.9 billion for drought assistance in addition to nearly $3 billion budgeted under existing programs for emergency feed assistance and federal crop insurance payments.

The federal agencies managed reservoir projects to best use the drought-reduced water resources, meeting the authorized project purposes while also maintaining minimum flows for fish and wildlife and water quality in the rivers below the projects. In virtually every area serviced by the Bureau of Reclamation's 225 multi-purpose water projects, deliveries in 1988 from storage reservoirs plus available ground water supplies were sufficient to meet water needs. While a few areas received only 60 percent of their regular supply, most users served by Reclamation project water did not suffer catastrophic drought impacts felt in other areas of the country.

The Corps of Engineers undertook extensive dredging operations to maintain the principal rivers of the inland waterway system that experienced record low levels. Up to 13 dredges worked in the most severely shoaled areas of these rivers. The Corps, Coast Guard, and barge operators worked closely to coordinate traffic demands, monitor channel conditions, and minimize delays. While the Mississippi River mainstem experienced numerous closures, the Tennessee Tombigbee Waterway provided an alternative route from Cairo, Illinois, to the Gulf for some shippers. The Corps also regulated flows from Lake Lanier to maintain water supply and quality for metropolitan Atlanta and constructed an underwater barrier in the Mississippi River below New Orleans to stop the upstream migration of the saltwater wedge which threatened the water supply intakes in the vicinity of New Orleans.

Outlook for reservoir levels for 1989 is speculative in many regions since reservoir storage is highly dependent on late winter and spring precipitation. In 1988, a high degree of coordination, extensive dredging, and water control management were required to keep the inland navigation system open to commerce. Response to the 1988 drought was extensive and effective. However, formal, planned drought management has not been a major federal focus. With some predictions of potential future climate changes, consideration of drought management is likely to become an important water resources issue.

Infrastructure

The National Council on Public Works Improvement recently completed its work and concluded that the quality of America's infrastructure is barely adequate to fulfill current requirements and insufficient to meet the demands of future economic growth and development.[97] Generally included in infrastructure are such public works projects as navigation channels and ports, flood control works and other water resources projects, highway, mass transit systems, and aviation, water supply, wastewater, solid waste, and hazardous waste facilities. One of the recommendations of the Council was that the problems with the nation's infrastructure must be addressed by all levels of government.

In the 100th Congress, several infrastructure bills were introduced. None was enacted, but the involvement of the federal government in infrastructure, including water resources projects, is likely to remain under discussion.

Global Climate Change

There is a some evolving scientific evidence that we may be moving towards a global climate change believed to result from the increase in concentrations of carbon dioxide and other greenhouse gases (nitrous oxide and chloroluorocarbons) in the atmosphere. The type of emissions amounts, and resulting impacts are being studied by the international scientific community. The concern is that global warming might impact on weather patterns, including the amount and distribution of rainfall and cause a rise in the eustatic sea level rise. Whether these changes will occur, and if so when, is unknown. However, as scientific study advances it may be prudent to explore ways to reduce emissions and to plan for the consequences of climate change.[98]

Relative sea level rise, which includes the eustatic sea level rise and the changes in landform (subsidence or rebound), is detectable. Results of research efforts, special studies, and reports by the National Research Council and other activities have led to the conclusion that planning for future coastal projects must consider the impacts of different rates of relative sea level rise. Consideration of the impacts in the coastal environment should also be made.

Predictions of seasonal and geographic changes in precipitation patterns are the most difficult. Results of various computer modelling efforts to date have not provided consistent predictions, thus the issues of uncertainy and reliability remain. Fortunately, most water resource projects are designed to accommodate variations in annual precipitation. When available, knowledge of significant variations from current patterns will provide the necessary basic

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Defense Lands and Installations

4

> *Defense is more than planes and missiles to protect the country against an enemy attack. Part of the defense job is the safeguarding of the land, timber and waters, the fish and wildlife, the priceless natural resources which make this country worth defending.*
>
> General Thomas D. White,
> USAF, Chief of Staff
> (1957-1960)

Located in the southwestern corner of Arizona is a huge tract of desert land, covering more than 4,000 square miles, with 23 mountain ranges and some peaks rising more than 4,000 feet. A recent Department of the Interior study called it "the best reserve of unspoiled desert in the Southwest." But it is also a vital military installation. The Barry M. Goldwater Air Force Range is the largest range in the free world dedicated exclusively to the training of military pilots. Virtually every fighter pilot in the nation trains on this range at some point in his career. The most modern jet fighters of the Air Force, Navy and Marine Corps dive, twist and turn in the clean, dry desert air.

Beneath the jets, the plants and animals of the desert prosper in this unspoiled environment. This is no accident. Careful planning, outstanding management and a dedicated effort by hundreds of people made this possible. Faced with deterioration of the pristine desert as a result of increasing military and public demands, a concerted effort was made to develop a long-term national resources management plan. combining the resources, expertise and experience of the Department of Defense, U.S. Fish and Wildlife Service, Bureau of Land Management and the Arizona Game and Fish Department. With assistance from the University of Arizona, the most comprehensive and integrated natural resources management plan ever accomplished for a military range was developed and implemented. Recognizing the delicate relationship among the land, wildlife, recreation, cultural resources, multiple-agency jurisdictions and community concerns, a comprehensive strategy was adopted so that all of these considerations could be addressed simultaneously. The land and habitat of this national treasure is being protected, restored and effectively used, ensuring its continued healthy contribution to the desert ecosystem of the Southwest United States.

The vast expanse of this desert provides the world's only safe haven for the sole surviving herd of Sonoran pronghorn Antelope. Bighorn sheep also thrive in the rugged, isolated mountains of the Goldwater Range. Preserved in its arid climate and desert soils are prehistoric and historic artifacts recording more than 10,000 years of desert civilizations. The land is adorned with 400 varieties of plants, including some endangered and unusual species. There are 62 species of mammals, more than 200 species of birds, 8 amphibian species and 37 species of reptiles that make this land their home. In every sense of the word, it is a national treasure, an unspoiled desert of beauty and ecological significance.

To recognize this effort, the Barry M. Goldwater Air Force Range received the Secretary of Defense 1987 Natural Resources Conservation Award. In 1962, the Secretary of Defense established the Conservation Award to provide suitable recognition to installations that design and implement exemplary programs for the conservation and protection of the natural beauty, productivity and ecology of DOD lands.

The Secretary of Defense Award was modeled after a conservation award program established in the Air Force by General Thomas D. White, USAF, who served as Chief of Staff from 1957-1960. General White saw natural resources conservation as an essential element of national security. Each year the Air Force nominates the winner of its General Thomas D. White Award to compete for the Secretary of Defense Conservation Award. In the competition for the prestigious Conservation Awards, each of the military departments nominates an installation and an individual. A panel of prominent conservationists judge the nominees according to certain criteria, including:

- leadership attitudes and community involvement
- education programs
- land management planning
- increasing access for outdoor recreation
- quality of fish and wildlife programs
- law enforcement and protection of endangered species and their habitats
- quality of forestry programs
- protection of natural areas
- water conservation and soil erosion control programs
- cooperation with federal, state and local agencies and universities
- beautification and landscaping programs.

In 1973, a separate Environmental Quality Award was added to the program to recognize outstanding work by military installations in abating and preventing pollution. A roster of award winning installations appears as Figure 1.

Natural Resources on Defense Lands

As steward of nearly 25 million acres of real property — an area 20 times the size of Delaware — and more than 2 million acres overseas, the Department of Defense faces the challenging task of conserving and restoring the land, air and water entrusted to it. The land assigned to individual installations may consist of only a few acres, in the case of a weather station or radar site, or, like the Goldwater Range, it may stretch to more than a million acres, with forest, beaches, desert, wetlands, tundra and every topographical configuration known. On this land, and in the air and water, is a wide diversity of plant and animal life indigenous to all regions of this nation, and to many other parts of the world.

Long before the public's concerns about environmental protection became formalized in federal regulatory programs, the military services took the initiative on land maintenance programs and management of fish and wildlife, employing modern methods of forest management, fish and wildlife conservation, erosion control and the abatement of air, noise and water pollution. This early commitment to environmental protection and conservation has evolved into well-defined, formalized and integrated natural resources and environmental policies. As a result, full consideration is given to the improve-

Nonforested Lands

Nonforested areas ranging from natural deserts to tundra to areas cleared for airfields and other mission uses make up the majority of Defense lands. Intensive programs for managing these areas date back to the 1940's. When it was realized that dust and erosion were adversely affecting the life of aircraft engines and other delicate equipment as well as the health and safety of people, professionals were hired and massive programs were undertaken to bring erosion under control at many installations denuded by construction or training activities. Many of these installations were located in dry climates with ideal weather for year-round training but with great potential for erosion. Today, Department of Defense installations have modern land management programs which have expanded beyond simple erosion control. They support the broadest multiple uses of the land for mission purposes as well as for agriculture (outleased to local farmers and ranchers), wildlife conservation, outdoor recreation and natural beauty.

Wildlife Habitat

Since September 25, 1960, the Sikes Act (16 U.S. Code 670) has authorized the Secretary of Defense to carry out a program to develop and conserve fish and wildlife on military reservations in cooperation with the Secretary of the Interior and the states. The cooperative plans developed under the Act were to be consistent with any overall management plan for the lands involved and the military's missions. The Sikes Act established a basic link for the Defense Department's implementation of a coordinated program to carry out its stewardship responsibilities.

The Department of Defense is now working with the Fish and Wildlife Service to identify areas on military installations that are or have potential to be excellent waterfowl habitat. This cooperative effort is in support of the North American Waterfowl Management Plan – a joint Canada-U.S. venture to reverse the declining population of waterfowl in North America. An agreement signed by Frank Dunkle, Director of the Fish and Wildlife Service, and William Parker, Deputy Assistant Secretary of Defense, lays out the cooperative plan. Military bases in or near critical waterfowl habitat areas (as described in the North American Waterfowl Management Plan) are being evaluated for their potential to benefit waterfowl. Fish and Wildlife will assist DOD to revise wildlife management plans at installations selected. Then DOD will implement those management plans. This is but one example of the effective methodology so often employed by DOD to manage natural resources wisely. There are many examples of cooperative work with universities, Forest Service, EPA, Park Service and host states. This methodology is not only efficient because DOD doesn't duplicate technical expertise readily available elsewhere in the government, but is also the method by which the public can benefit most broadly from the knowledge and results gained from the projects.

Resource Management Mission: Selected Cases

■ At **Tyndall Air Force Base** in Florida, the beaches on the installation were used for recreational off-road vehicles, Navy hovercraft training and military exercises. However, the beaches were also nesting grounds for endangered sea turtles and state-protected birds. In 1982, Air Force environmental officials discovered that the extensive activities on the beaches were destroying nests and hatchlings, and preventing full nesting potential from evolving. A program was designed to enforce natural resource protection regulations and, by 1985, the nesting rate of sea turtles nearly doubled. Vehicle traffic on the beaches decreased substantially, and sand dunes began to regenerate and reseed. Sea oats, a valuable source of food in the habitat, became abundant. Local citizens saw the change taking place on the Tyndall beaches, and petitioned local governments to restrict vehicle traffic on their beaches as well. As a result of the military's initiative in protecting and restoring the natural resources at Tyndall, citizen involvement resulted in considerable beach habitat improvement outside the boundaries of the Air Force base.

■ At **Fort Carson**, Colorado, only about 12 inches of precipitation falls each year, precluding the rapid recovery of natural resources affected by intensive military training activities. Mechanized infantry training has been underway at Fort Carson since 1962, and some areas of the installation suffered environmental damage. Trees that take hundreds of years to grow can be wiped out in a matter of seconds by tanks and heavy trucks. Vegetative cover and trees are essential for realistic training. The Army took the initiative to acquire more land for training, allowing it to take steps necessary to repair damaged portions of the land previously used for training. In order to minimize future damage to the new land tract, a comprehensive plan for natural resources management was developed, and more than $6 million was spent for seeding, land treatment, erosion control and technical studies. The new training area is divided into five parcels for management purposes. Only three of the five parcels are used at one time, so that the other two parcels can be repaired and rested.

■ **Camp Pendleton** is a Marine Corps installation located between the sprawling San Diego and Los Angeles metropolitan areas. Due to increasing development around those major cities, Camp Pendleton is the last relatively undeveloped area on the Southern California coast. With a land area of more than 125,000 acres and an installation population of more than 38,000, the military bases is used for amphibious force exercises; helicopter, artillery and bombing practice; and other essential military training operations. Along with these training activities, the base has become a sanctuary for several rare and endangered species. Camp Pendleton protects the highest density of nesting sites for the California least tern and the least Bell's vireo in North America. The base has a viable deer population and serves as a significant southern coastal wintering area for waterfowl. Because of its sufficient water supply and frost-free climate, the base, as part of its agricultural outlease program, accommodates the testing and certification of more than 60 percent of the seed potatoes grown in the United States.

- The **Avon Park Bombing Range**, 106,000 acres of sandhills and wetlands in central Florida, was used extensively for cattle grazing before coming under military management. Pastures were not fertilized or rested. Wetlands had been drained to produce more pasture land. Forestry activities were conducted in a haphazard manner. To rectify the situation, the Air Force developed a natural resources management plan which included more than $100,000 worth of land improvements to sustain the productivity of natural resources and enable multiple use of the property. As a result, wetlands are preserved and carefully managed. Forests were regenerated to produce income from harvesting while still providing a good habitat for wildlife. Specific protection was provided for endangered and threatened species. Now more than 3,000 people participate annually in hunting, fishing and other outdoor recreation activities at Avon Park. The natural resources management program conserves the area, while still supporting necessary military requirements and allowing public recreational and commercial use.

- Due to increasing concerns about the deterioration of military lands, the Army has developed a computer-based system to help planners and natural resources managers monitor erosion and landcover degradation. The system uses a geographic information program in conjunction with the Universal Soil Loss Equation to locate and analyze highly erodible areas. This method has been used at **Fort Hood**, Texas, to classify training lands according to their ability to support military training. The classification system has also been used to inventory Fort Hood's current land conditions, schedule training activities to avoid severely degraded or highly sensitive areas, to group sites of similar capabilities, to schedule land rehabilitation efforts, to help make natural and cultural resources management decisions and to evaluate proposed new land use.

- **Indian Island**, a Navy installation near the entrance to Puget Sound in Washington, consists of only 2,700 acres. Despite its size, its natural resources management program has effectively produced a marsh, a bird sanctuary, a heron rookery, a healthy deer herd, nesting eagles and miles of beaches teeming with clams. A wondrous virgin Douglas fir forest is carefully preserved. Indian Island is just one of many small parcels of land under the stewardship of the Defense Department, such as radar sites and storage bunkers. Nevertheless, the DOD natural resources conservation program applies to those just as it does to the military installations covering enormous land areas.

The Department of Defense is thoroughly committed to protecting the environment, while at the same time accomplishing its primary task of defending the nation. Through long-range planning, adequate financing and communicating with other agencies and the public, along with the hard work of thousands of dedicated people, the Department of Defense will continue to conserve and protect the land, air, water and other resources entrusted to its stewardship.

Military Use of Non-Defense Lands

The military departments supplement, when necessary, the training lands they manage with about 15 million acres of land managed by other federal agencies and states. In 1988, the Secretaries of Defense and Agriculture signed a new Master Agreement for Military Use of National Forest System Lands. The agreement contains policies, procedures and responsibilities pertaining to the use of national forests for military training activities on the ground. It calls for early and cooperative NEPA compliance when new or modified exercises are proposed, and for incorporation of routine military use into forest management plans and environmental impact analyses. Supplemental agreements are authorized locally to address specific responsibilities, procedures, monitoring, mitigation and other appropriate features. DOD is now developing a new directive that will govern military use of all non-DOD lands for training exercises. The main focus of the directive will be early incorporation of the NEPA process to avoid land use conflicts later when they are more difficult to resolve.

One of DOD's major challenges in the 1990's will be using its land and airspace to accomplish missions. Advancing technology produces combat support systems that require larger areas to test them and train with them. At the same time, there are increasing pressures to share DOD lands for other uses. As population and the expectation for an improving quality of life increase in the United States and worldwide, even as the amount of land and airspace remains fixed, DOD finds it more and more difficult to compete successfully for the space needed to maintain an adequate national defense posture. The Land and Airspace Working Group within the staff of the Secretary of Defense is seeking ways to improve coordination and efficiency in DOD's use of land and airspace as well as ways to improve communications and effectiveness to satisfy those needs of the Department in the future.

Historic Preservation

As stated in the National Historic Preservation Act of 1966, it is the policy of DOD to administer prehistoric and historic resources in a spirit of stewardship for the inspiration and benefit of present and future generations. DOD's role in the protection of historic and archaeological properties has evolved over the last hundred years. In the mid-19th century when Congress became interested in commemorating historic events, it turned to the War Department to manage federal lands acquired for that purposed. From 1880, when the War Department was given responsibility for maintaining the first national battlefield monuments, Chickamauga and Chattanooga, until these areas were turned over to the National Park Service in 1922, the War Department managed over 25 battlefield sites and military parks. During the same period, there was also a growing public interest in the archaeological sites in the western part of the country. This led to the passage of the Antiquities Act of 1906, which authorized the President to set aside land with significant cultural or scientific resources and made illegal the disturbance of archaeological sites on federal land without a permit issued by the Departments of Agriculture, Interior or War. The increasing role for government in the identification and preservation of historic resources was recognized by Congress with the enactment of the Historic Sites Act of 1935 which established a national policy of historic preservation and authorized the Secretary of the Interior to initiate a national program. In 1966, that policy was enhanced by the requirements of the National Historic Preservation Act. The 1966 Act, and its amendments, requires all federal departments and agencies to identify the historic buildings, structures, districts and sites that meet the criteria of the National Register of Historic Places. That activity must be undertaken in consultation with the State Historic Preservation Officer (SHPO) and the President's Advisory Council on Historic Preservation.

Currently, there are hundreds of sites on Defense installations listed on the National Register. These include individual buildings, structures and sites as well as districts, such as the U.S. Military Academy at West Point, New York.

The history encompassed in these places spans about 12,000 years, from the oldest archaeological sites, to structures of the atomic age, such as the Trinity Site at White Sands Missile Range in New Mexico. Much of this history is related to the maintenance of a fighting force in the United States. As the oldest agency of the federal government, the Defense Department maintains properties that were fortified for the Revolutionary War (West Point, New York); laid out in the 1791 L'Enfant plan for Washington, D.C. (Fort McNair); part of the coastal defenses during the War of 1813 (Fort Monroe, Virginia); designated as an arsenal in 1812 (Watervliet, New York); part of the string of installations built to open the West (Fort Leavenworth and Fort Riley, Kansas, and Fort Sam Houston, Texas); and build to support World War II (Fort Wainwright in Alaska).

Properties Acquisition

As the federal government acquired land and transferred it to DOD, it often obtained buildings and archaeological sites that are related to earlier occupation of the land. In the northern most part of the State of New York, the Army is now using land that was settled by a French emigre in 1806 who was important in guiding the agricultural development of that area of the state. Today, his mansion is used as visiting officers' quarters and the remains of the estate and adjoining village are being documented as part of a comprehensive, multi-year archaeological program. In Monterey, California, the Army now manages land hallowed by the Spanish explorers who landed there in 1602 and who established a presidio and mission on the same site in 1770. Camp Pendleton Marine Corps Base in California used to be a major land grant to the Pico brothers, which they named Rancho Santa Margarita. The Marines acquired the majority of the land in 1942. Other installations contain historic places dating back to the early 18th century, including a hacienda designed by the first registered woman architect in California for one of the wealthiest ranch owners in the United States. Archaeological sites on Defense lands are associated with an ancient temple in Hawaii, the adaptation of man to the change from Lake Mojave to the Mojave Desert, Ice Age activities in central Texas, the mound builders of the Mississippi region, the native cultures first contacted by Europeans, as well as with 18th and 19th century settlers and their changing industrial, agricultural and domestic systems.

To meet the requirements of the National Historic Preservation Act, the Army issued a regulation that delegates responsibility for compliance with the Act to each installation commanding officer and requires installations with historic properties to prepare historic preservation plans. The plan must include procedures for inventorying the historic and archaeological places, evaluating their significance and determining how the historic places should be treated. The plans are coordinated with the appropriate SHPO and the Advisory Council.

Historic Buildings

In the case of historic buildings, in addition to the challenges involved in maintaining old building materials and techniques, there are a number of other issues the preservation program addresses. These include trying to find adaptive uses for the historic buildings. As the military's needs change so do the uses and occupants of the buildings. Historic hospitals are abandoned for new medical facilities or obsolescent stables for new vehicle sheds. In both of these cases, the history of military medicine and of cavalry units is reflected in the history and design of these buildings. For both historic preservation and economic reasons, DOD looks for adaptive uses of these buildings, often making the hospital into the installation headquarters or rehabilitating the stables for machine shops.

There are over 2,000 quarters on Army installations alone which have been identified as historically significant and are still used for housing families. These quarters are a major contributor to the historic character of the installations and are frequently associated with former military leaders, such as Robert E. Lee, George S. Patton, Dwight D. Eisenhower and others. Congress has asked the Army to survey all the historic family quarters to assess the suitability of these structures with respect to current housing standards. The survey will identify the work required to bring the quarters up to housing standards and to maintain or repair the significant historic and architectural features.

Other issues affecting historic buildings is energy consumption and maintenance costs. In particular, there are many thousands of old single-pane wood windows in historic buildings that are difficult and expensive to maintain (scraping and painting) as well as contributors to high energy costs. Other challenges include incorporating new buildings into historic districts. In such cases, site design may necessitate demolishing an historic building and incorporating features in the new building that will make it compatible with the adjacent historic buildings. However, prior to any demolition or substantial alteration of a historic building, it is recorded by using the standards of the Historic American Buildings Survey/Historic American Engineering Record, and the records are deposited in the Library of Congress for use by the public.

Archaeological Sites

DOD's archaeological program has developed in response to the fact that its installations contain sites associated with a large spectrum of cultural history. Additionally, since most military installations are located in areas away from major cities and where the intensity of land use has been slight, many sites are well preserved. The DOD program, in the long-term, is undertaken to make a significant contribution to the public's cultural knowledge. In the short term, however, the program is driven by the intensity of the military's impact on sites and the need for data to evaluate and interpret the archaeological record being impacted.

Studies at Fort Hood, Fort Bliss and Fort Leonard Wood show that sites near or on the surface are damaged more from tracked and wheeled vehicles than from any other impacts. Damage from impacts such as vandalism, exploding ordnance, excavation and recreation is substantially less. For these reasons, the Army gives highest priority to identifying archaeological sites located in training areas. Some maneuver areas contain hundreds of thousands of sites and there is usually insufficient time to analyze all of them before the military needs to use the area. In many cases, however, there is enough information about the sites to select a statistically valid representative sample of each site type and to group those samples in an area or "district," which is then placed off limits to military training.

To further protect site location data, discourage vandalism and integrate the districts into the training scenario, these areas are designated nuclear, biological or chemical warfare areas so that entering such areas is tantamount to losing the "battle." When there are sufficient plants nearby, sites are camouflaged to discourage tank drivers from entering the areas. In some cases, the military cannot avoid the districts. In those cases, testing or excavation necessary to obtain the data needed to respond to research problems is undertaken. Because field work is so labor intensive and expensive, excavation is usually limited to those sites where there is a high probability of there being important and unique data.

Records and artifacts are maintained on installations or in nearby facilities where they are available to the public. Installations are encouraged to provide information about the archaeological projects to the public in leaflets, exhibits and technical reports. Since about 90 percent of the archaeological field surveys, analysis and data recovery is done under contract to private firms, a great deal of the information is immediately available for use in scholarly papers and publications. The history and pre-history of large parts of California, Colorado, Louisiana, Missouri, New Mexico, New York, Texas and Washington have been rewritten as a result of DOD's archaeology program.

DOD's program has been evolving since the early 1970's to achieve four goals: to preserve places associated with the history of the military and of America; to integrate historic and archaeological resources management with the long-term management of the installations; to meet high professional standards of historic preservation; and to educate citizens about the historic and archaeological resources on military lands. The Defense Department is proud of its significant contribution to the history of this nation and the world and strives to protect historic places on its lands for future generations.

Environmental Quality and the Acquisition Process

A staggering amount of the Defense Department's resources are directly and indirectly focused on the research, testing, production, use and disposal of military materiel and systems. Several initiatives are designed to better integrate environmental planning, pollution abatement and conservation into what DOD calls the Acquisition Process.

The Management of Defense Systems

In the Defense Acquisition Process there are periodic milestones at which a high-level executive panel, called the Defense Acquisition Board (DAB), reviews the status of a major system and decides whether to proceed with further development. A comprehensive analysis of the existing data and planned activities is provided to the DAB by DOD staff and by program managers. New and revised regulations are being prepared to enhance the use of environmental planning in that process. Additionally, efforts are underway to add awareness of the benefits of doing that to the curriculum at the Defense Systems Management College at Fort Belvoir, Virginia.

Source Reduction Program

Among other things, the Defense Logistics Agency (DLA) reviews and revises federal, military and commercial procurement requirements. DLA established a Source Reduction Program in March 1987 to find non-hazardous or less hazardous alternatives to the formulations and industrial processes historically and currently used. Changes to specifications and standards are then promulgated to incorporate the non-hazardous or less hazardous alternatives. DLA considers present and anticipated hazardous waste generation, historical procurement information, safety and health concerns, present and proposed domestic and international regulations, potential legal liabilities and evolutionary technologies. This source reduction effort encompasses asbestos, chloroflorocarbons and halons, fuel additives, heavy metals, coating and plating processes, other manufacturing processes and product formulations and solvents.

The Defense General Supply Center (DGSC) in Richmond, Virginia, is the center for the source reduction effort. DGSC's efforts won the DOD Standardization Accomplishments Award for 1988. Notable successes were the development of the prototype DOD Hazardous Materials Information System and the first comprehensive version since 1963 of federal Specification P-D-680, Dry Cleaning Solvent. Now, new solvents purchased are not classified as ignitable hazardous material. A subsequent cooperative effort for antifreeze compounds, their additives and other solvents has begun. Military Specification MIL-H-87111, Heat Sink, Electrical-electronic Component, is being revised to require DOD acquisition of nonhazardous heat sinks and insulators with an approximate cost savings of 75 percent.

Military Specification MIL-C-2463, Electrical Cable and Cord, For Shipboard Use, is being revised to prohibit the use of polyvinyl chloride as an insulating material. Less hazardous compounds are being substituted, so that burning cannot generate chlorine gas in restricted spaces aboard aircraft and ships.

Non-Government Standard A-5 from the American Food Preservers Association and non-government Standard Series 1S-4 from the National Wood Windows and Doors Association are being substituted for Government standards for the preservation of wood construction materials purchased for DOD use. This will result in the acquisition of wood materials with less or non-hazardous preservatives in lieu of hazardous pentachlorophenol preservatives. In the review of other manufacturing processes and chemicals, particular attention is being paid to the elimination of heavy metal compounds and hazardous coatings.

The Defense Fuel Supply Center, in cooperation with the Department of Energy and the National Institute of Petroleum Energy Research, is identifying alternatives for the injection of a fuel system icing inhibitor into DOD bulk fuels as well as determining the hazardous waste potential of fuel additives and fuel by-products.

The Defense personnel Support Center in Philadelphia will begin a source reduction review program in 1989 for medical items used by the military.

The Army and Environmental Protection

The Army exercises stewardship for 12 million acres of public land and uses 15 million acres of leased land at 1,391 sites in the United States and overseas. To promote environmental protection and enhancement, the Secretary of the Army has adopted the seven environmental quality goals (see box), including demonstrated leadership. Several recent actions demonstrate that commitment to leadership.

data to formulate water resource projects to meet the changing needs and reduce the adverse impacts.

It may be necessary, however, to plan future projects considering climate change even before all the uncertainties are known. In the interim, support of necessary new research and thorough evaluation of ongoing and completed research is needed.

There are numerous scientific and governmental initiatives under way to address global climate change. For example, the United States has joined with 40 other countries in the Intergovernmental Panel on Climate Change under the leadership of the United Nations Environment Programme and the World Meteorological Organization. The goal is to issue a report in late 1990 on the scientific basis for assessing climate change, what the impacts would likely be, and strategies to deal with the changes, either by stabilizing or reducing change or adapting to it. These and other similar efforts will lead the way into the next century in managing water resources development in consideration of potential climate change.

Ground Water

As a result of investigations into the environmental impacts on ground water of such potential sources of contamination as hazardous waste disposal sites, underground storage tanks, domestic septic systems, agricultural practices and others, federal agencies have undertaken some recent initiatives to improve the information base for policy evaluation and the government's institutional capabilities to protect groundwater.

Congress has also considered this matter and legislation was proposed, although not enacted, to achieve the following general objectives.[99]

1. Collect and summarize the scientific information available regarding the broad area of groundwater and its characteristics, quality, quantity, rate of depletion, locations, hydrogeological properties, etc.;
2. Identify significant knowledge gaps;
3. Conduct research programs to study details of detection, monitoring, extent and mitigation;
4. Develop technologies to control sources of groundwater contamination;
5. Conduct demonstration projects which will be cost shared with non-federal agencies and groups;
6. Integrate information into management programs that provide protection and remediation of groundwater resources; and
7. Conduct educational programs for all levels of the populace on protection of the ground water resources.

The President's FY 1990 budget request to Congress includes a new ground water quality initiative which addresses these points,[100] and which defines the proper role for federal agencies in cooperating with states to deal with significant problems that are identified.

The fundamental reforms in water resources policy that became possible during the 1980's can be viewed as a positive environmental legacy, as well as a restoration of a rational water resources development program. Through active cooperation among many diverse interests, the cost sharing policy provides a framework for moving forward where the development need has been clearly demonstrated, consistent with a high quality environment, and in true partnership with state and local interests. Much remains to be done to implement these reforms, but the policy principles are now well established through their application to the present program, and promise to continue to serve the nation well.

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Figure 1. Environmental Quality and Natural Resources Conservation Awards

The Secretary of Defense

Environmental Quality Awards: 1973-1987

1973	Fort Sill, Oklahoma
1974	Eglin Air Force Base, Florida
1975	Patuxent River, NATC, Maryland
1976	Kaneohe Bay MCAS, Hawaii
1977	Camp Pendleton Marine Corps Base, California
1978	Fort Sill, Oklahoma
1979	McCellan Air Force Base, California
1980	Camp Lejeune Marine Corps Base, North Carolina
1981	Hill Air Force Base, Utah
1982	Fort McClellan, Alabama
1983	Luke Air Force Base, Arizona
1984	Kaneohe Bay MCAS, Hawaii
1985	Fort Lewis, Washington
1986	Pine Bluff Arsenal, Arkansas
1987	Vandenberg Air Force Base, California

Natural Resources Conservation Awards: 1962-1987

1962	Fort Knox, Kentucky
1963	Eglin Air Force Base, Florida
1964	Tyndall Air Force BAse, FLorida
1965	Yorktown Naval Weapons Station, Virginia
1966	Fort Rucker, Alabama
1967	Tyndall Air Force Base, Florida
1968	Camp Lejeune Marine Corps Base, North Carolina
1969	Camp Pickett, Virginia
1970	Tyndall Air Force Base, Florida
1971	Camp Pendleton Marine Corps Base, California
1972	Camp Lejeune Marine Corps Base, North Carolina
1973	Fort Campbell, Kentucky
1974	Barksdale Air Force Base, Louisiana
1975	Camp Lejeune Marine Corps Base, North Carolina
1976	Griffis Air Force Base, New York
1977	Fort Sill, Oklahoma
1978	Chase Field Naval Air Station, Texas
1979	Fort Huachuca, Arizona
1980	Tobyhanna Army Depot, Pennsylvania
1981	Fort McCoy, Wisconsin
1982	Indian Island Naval Engineering Station, Washington
1983	Fort Huachuca, Arizona
1984	Robins Air Force Base, Georgia
1985	Beale Air Force Base, California
1986	New Boston Air Force Station, New Hampshire
1987	Barry M. Goldwater Air Force Range, Arizona

ment and enhancement of our environment, including extensive recreation use of our military installations by the general public.

The Defense Department continually conducts reviews to identify those lands no longer needed for its missions. As a result of this aggressive program, more than 1.5 million acres of land has been removed from the inventory. This land has been made available for parks, outdoor recreation and other public or private use.

Forested Lands

Forest management is also a cornerstone of the DOD natural resources program. As early as 1823, 30,000 acres of forested land on Santa Rosa Island near Pensacola, Florida, was the first federal land set aside for forest management. The predominant species, live oak, was managed for years as a renewable supply of timber for shipbuilding. During the Civil War, mills were operated by engineer units all over the South. The wood was used for trench and tunnel construction, corduroy roads, abatises and bridges. The Army's formal management of forests began in 1903 when the first forest management plan was approved by the Secretary of the War for the Military Academy at West Point, New York. The Clark-McNary Act of 1924 made forested military installations National Forest Units. Fort Benning in Georgia; Fort Jackson, South Carolina; and Fort McCellan, Alabama, were under this program, jointly managed by the Forest Service and the War Department. The program was discontinued in 1927 at the request of the Forest Service.

About 80 percent of the Department of Defense's present forested land was acquired during World War II, and was previously used for agriculture or timber harvesting. By 1960, nearly all Department of Defense installations with significant forested land had forest management plans. At that time, funding for forest management was dependent on appropriations from Congress, and typically received very low priority in competition for funds. Beginning in 1961, Congress annually included a provision in the Department of Defense Appropriations Act that allowed reimbursement of expenses for forest management from sales proceeds. With this change, forest management in the Department of Defense achieved stability and impetus. In 1977, this reimbursement authority was made permanent. In 1981, the law was amended to provide host states with 25 percent of installation's net proceeds, and amended again in 1984 to increase host states' entitlements to 40 percent. Currently, nearly 200 Department of Defense installations manage about 2.3 million acres of forested lands for various uses. It provides good wildlife habitat, outdoor recreation opportunities, commercial harvesting and military training and buffer zones.

United States Army Environmental Quality Goals

Although the primary mission of the United States Army is national defense, we are committed to protecting our environment and conserving our natural resource heritage both for ourselves and future generations. To assure fulfillment of our commitment, the Army has adopted the following environmental quality goals:

- Demonstrate leadership in environmental protection and improvement.
- Minimize adverse environmental and health impacts while maximizing readiness and strategic preparedness.
- Assure that consideration of the environment is an integral part of Army decision making.
- Initiate aggressive action to comply with all federal, State, and local environmental quality laws.
- Restore lands and waters damaged through our past waste disposal activities.
- Support Army programs for the recycle and reuse of materials to conserve natural resources, prevent pollution and minimize the generation of wastes.
- Pursue an active role in addressing environmental quality issues in our relations with neighboring communities.

To these environmental quality goals, the United States Army remains irrevocably committed.

Environmental Compliance Achievement Program

Although the Army has made significant progress in recent years toward abating pollution and managing hazardous waste, the increasing number and complexity of laws and regulations make future compliance a real challenge. To promote compliance, the Army is developing an Environmental Compliance Achievement Program (ECAP). It is designed to improve the Army's environmental compliance auditing. With the information obtained from the audits, projects needed for compliance at Army installations can be identified and funds requested. The ECAP involves all organizational levels and reinforces the Army's commitment to the protection of the environment.

Environmental Quality Awards

The Army has won the Secretary of Defense Environmental Quality Award five times since the Award program began in 1973. For her work at Fort Huachuca, Arizona, Danita Hardy was selected as the winner of the 1987 Environmental Quality Individual Award. Ms. Hardy's accomplishments include completing a thorough environmental analysis for tests proposed to occur in a sensitive riparian area adjacent to a prehistoric Indian village, relocating test activities to avoid damaging valuable archaeological and riparian sites, and developing a computer data base to track hazardous waste.

The last three Army winners of the Secretary of Defense's Environmental Quality Installation Awards (Pine Bluff Arsenal, Arkansas in 1986; Fort Lewis, Washington in 1985; and Fort McClellan, Alabama in 1982) demonstrated conscientious and excellent compliance with the National Environmental Policy Act.

Environmental Law Division

The Secretary of the Army recently approved the creation of an Environmental Law Division in the Office of the Judge Advocate General. This is another indication of the steps being taken to improve environmental compliance at Army installations. By establishing this single focus for environmental law matters on the Army Staff, the Army can be more responsive to and avoid problems involving legalities.

As part of its job, the new law division will supervise annual training of Army installations' environmental attorneys.

Environmental Decision Making

One of the objectives of the National Environmental Policy Act (NEPA) is to promote environmental values in the federal decisionmaking process. The Army issued new regulations implementing NEPA on December 16, 1988 (32 CFR Part 651). These regulations include a requirement to make consideration of the environment an integral part of Army decision making.

The Intermediate Nuclear Forces (INF) Treaty

On December 8, 1987, the President of the United States and the Soviet Union's General Secretary of the Central Committee of the Communist Party reached agreement on the elimination of intermediate range and short range missile systems. The Army spent many hours behind the scenes preparing an environmental assessment (EA) in accordance with NEPA. The Legislative EA was sent to the U.S. Senate for its deliberations on whether to ratify the INF Treaty.

analysis of these data. GRASS is a prominent geographic information system and thus is being used by a number of other agencies in addition to DOD.

When GRASS is used at the installation level, its value is very apparent. GRASS has been used to site new landfills, firing ranges, maneuver areas and housing areas. It has been used to find new road and railroad corridors and develop a management plan for a multipurpose training range. It has been very useful during preparation of environmental impact assessments, and to periodically generate maps to help monitor the effects of training and to identify highly stressed areas.

At Fort Hood, Texas, GRASS is used extensively by environmental managers and other planners. For example, the Training and Range Control Office gives the Environmental Office the previous month's training intensity data. This information is entered into GRASS, which rates each training area's degree of use and sensitivity. For the coming month, the Environmental Office identifies areas nearing their environmental limits and those that are not stressed. This information is given to training planners for scheduling purposes.

GRASS is improving the Army's environmental assessment process by facilitating the analysis of alternatives, using the best models and data and presenting relevant information to decisionmakers. It is a useful tool to better comply with regulatory requirements, use resources in a more efficient and environmentally compatible manner and serve the objectives and goals of the modern Army.

Integration of Plans and NEPA

To foster better decision making, the Army is integrating the NEPA process with other Army planning processes. The objective is to reduce delays, avoid duplication of data gathering and ensure that decisionmakers are fully informed of consequences.

Planning processes being integrated with the NEPA process include:

- Installation Master Plans
- Natural Resource Management Plans
- Stationing Plans
- Force Development Plans
- Material Acquisition Plans
- Hazardous Waste Management Plans
- Historic Preservation Plans
- Remedial Investigations/Feasibility Studies Asbestos
- Management Plans

Environmental Restoration

Environmental restoration is at the forefront of the Army's efforts to cleanup the environment. In 1975, five years before the Superfund law was passed, the Army was grappling with the realities of chemical pollution. One of the reasons the Army faced this challenge before the other military departments did is because the Army produces the munitions for the other DOD components as well as its own use.

The Army Installation Restoration Program (IRP)

First at Rocky Mountain Arsenal in 1974, and next at Weldon Springs Chemical Plant, the Army's IRP began to identify, assess and remove contamination on and migrating off Army installations as a result of prior manufacturing, testing, storage, or disposal. In 1976, the U.S. Army Toxic and Hazardous Materials Agency (USATHAMA) started the records searching process that the Environmental Protection Agency (EPA) now calls the Preliminary Assessment (PA) under the Superfund law. The Army expects to have completed PAs on all of its properties by the end of 1989.

So far, these PAs have disclosed 2,636 potential sources of contamination on 84 installations. Of those installations, Remedial Investigations and Feasibility Studies (RI/FSs) have been completed on 1,993 potential sources. Those studies indicate that 270 sources on 35 installations need remedial action. By the end of 1988, remediation will have been completed for 114 of those 270 sources. The Army's goal is to complete all RI/FSs by the end of 1992 and all cleanup by the end of 1994.

Funding through the Defense Environmental Restoration Account (DERA) has steadily increased. Highest priority is accorded to the Army installations that are listed on the National Priorities List (NPL). The Army's IRP funding in fiscal year 84 was $23 million; in fiscal year 89, it has reached $204.5 million. For the 6 installations that are proposed for the NPL, and the 15 that are on the NPL, installation restoration work is proceeding steadily.

For the cleanup of explosives, solvents and acids at Rocky Mountain Arsenal, which is the subject of a two-party agreement, the Army's costs are estimated to reach $55 million in fiscal year 89, or 25 percent of the Army installation restoration program budget. This amount is exclusive of the costs that Shell Oil Company, which is the other responsible party at Rocky Mountain Arsenal, will pay for removal of contamination resulting from their former pesticide manufacturing operations as a tenant at the installation. Total costs for cleaning up Rocky Mountain Arsenal may be as high as $700 million.

Driven by escalating prices for remedial measures at this and other installations, the Army is investing in research development, and demonstration projects to find innovative and more cost effective ways to treat and remove contaminants. One such advance is a prize winning vacuum system that extracts toxic gases from abandoned landfills used successfully at Twin Cities Army Ammunition Plant.

Twin Cities AAP is the first federal facility for which an interagency agreement was signed under Section 120 of the 1986 Superfund amendments. The Army is negotiating several such agreements with EPA and individual States for the 15 NPL and 6 proposed-for-NPL installations. Because these agreements are prerequisites to the final cleanup phase, the Army is focusing on completing these agreements as soon as possible.

Environmental Restoration of Formerly Used Defense Sites

The Army is the executive agent for DOD's cleanup of properties where contamination is traceable to former ownership or use by DOD. Following procedures similar to those employed in the installation restoration program, the Army removes hazardous and toxic materials, including unexploded ordnance, from former sites.

By the end of fiscal year 1988, 7,090 formerly-used sites were identified. Of these, 616 do not need restoration. Another 181 have been restored, and 1,966 others are being studies for appropriate remedial actions.

Hazardous Waste Minimization

Another important environmental quality goal of the Army is to "support Army programs for the recycle and reuse of materials to conserve natural resources, prevent pollution and minimize the generation of wastes." To reduce the amount of hazardous waste generated, the Army established a hazardous waste minimization (HAZMIN) program with specific reduction goals.

An executive-level hazardous waste minimization workgroup, formed in 1987, develops policies to support waste reduction. Studies have been initiated to evaluate waste reduction opportunities in both acquisition and handling of hazardous materials. Also, the Army is developing awareness and hazardous waste reduction awards programs to emphasize the program. The Army plans to modify its hazardous waste disposal funding policies in fiscal year 1990 in order to encourage waste reduction at the sites of generation.

The Army's goal is a 50 percent reduction of hazardous wastes by 1992 (half of 1985 levels). Source reduction and recycling, toxicity reduction, routine audits, economic analyses and management support are means to that end. The Army's industrial command has hazardous waste reduction goals for specific production processes, and major waste generators have a goal of eliminating all untreated hazardous waste by 1992.

The Army annually generates approximately 102,000 metric tons of hazardous waste. Ninety percent of that is produced by the Army's industrial activities. Hazardous wastes include solvents, batteries, industrial sludges and heavy metal wastes. During fiscal years 1987-1989, the Army will have spent $15.8 million to implement an array of hazardous waste reduction projects to include solvent recycling, waste segregation, sludge dewatering and neutralization. Holston Army Ammunition Plant, Tennessee, implemented several HAZMIN projects which reduced hazardous wastes by 90 percent. Badger Army Ammunition Plant, Wisconsin, won a 1988 Secretary of Defense Productivity Excellence Award for saving $1.758 million in disposal costs by selling waste acid for reclamation.

Redstone Arsenal HAZMIN Program

Redstone Arsenal is the home of the Army Missile Command. It also contains laboratories for performing research on solid and liquid rocket motors, firing areas for testing missiles and rockets, and a propellant manufacturing plant. Redstone Arsenal has aggressively pursued reducing its generation of hazardous waste since 1985. A major area of concern involved the open burning of waste propellants. Since 1985, the percentage of waste treatment by open burning has increased from 46 percent to 78 percent. Redstone Arsenal initiated a research and development program designated to demonstrate that Army munitions and missile systems can be demilitarized by safe, cost effective and alternative methods while avoiding many of the adverse environmental problems associated with open burning.

Redstone's research program, called Super Critical Demilitarization for Hazardous Waste Minimization, led to conceptual development and testing of an innovative process designed to demilitarize, reclaim and recycle ammonium perchlorate composite propellants. These types of propellants are typically employed in systems such as the Pershing II, NASA's space shuttle boosters and Titan IVs. The process has the potential to demilitarize hundreds of millions of pounds of propellant in a cost effective manner. Unlike other methods, the process entirely avoids the use of water and allows the reclamation of vast amounts of ammonium perchlorate which would then be available for use elsewhere. Ammonium perchlorate recovered from the process accounts for 75 percent to 80 percent of the waste propellant. This process would significantly reduce DOD requirements for open burning of wastes.

Anniston Army Depot HAZMIN Program

Anniston Army Depot is a major combat vehicle center. There, the Army's M60 tanks and the new M1 Abrams main battle tanks are repaired and overhauled. Industrial operations at the Depot generate large quantities of hazardous wastes, including paint sludge, obsolete ammunition, sludge from industrial wastewater treatment plants and solutions from chemical cleaning and finishing operations. To reduce the quality and toxicity of hazardous wastes generated, Anniston Army Depot is actively pursuing new methods and technologies. Anniston recently modified an automatic cadmium plating line used in refurbishing the barrels of the M60 and M1 tanks. The depot is also testing a paint sludge minimization system to reduce wastes generated from one of its eight waterfall spray paint booths.

The hazardous wastes generated from the automated barrel cadmium plating line consist primarily of cadmium and cyanide laden rinse waters. The plating process steps include cleaning, pickling, plating and dichromating. Rinsing is performed after each process step. Approximately 10,000 gallons per day of contaminated rinse waters containing cadmium and cyanide were discharged into a central sump and subsequently sent to a cyanide destruction unit prior to being discharged to a industrial wastewater treatment plant. Several modifications resulted in a reduction of the total volume of rinse water flowing to the treatment plant by 40 percent and reduced the concentrations of cadmium and cyanide in the waste water by 30 percent and 70 percent, respectively.

Other aggressive waste reduction programs, such as recycling solvents, reusing paint strippers and segregating treatment plant sludges clearly demonstrate Anniston Army Depot's commitment to reducing its generation of hazardous wastes.

Fort Bliss HAZMIN Program

Even though the Fort Bliss HAZMIN program is small, as compared to examples cited previously, it illustrates the Army's commitment to hazardous waste reduction at all installation and not just at industrial facilities. At Fort Bliss, they are evaluating all incoming hazardous materials. They first identify the process that use hazardous materials and those that produce hazardous wastes. They analyze whether the process producing the hazardous wastes could be eliminated or changed. By doing this, they will substantially reduce their waste disposal needs. For example, they found that battery acid wastes constituted 86 percent of all hazardous wastes on the installation. With the completion of a battery acid neutralization facility this year and the elimination of scale remover at the radiator repair shop, the volume of wastes is expected to decrease 95 percent by 1992.

The Navy and Environmental Protection

The Navy has made great strides in its environment program since the early 1970's. In the earlier years, Navy focused on getting permits for point discharges into the nation's waters, testing air emissions from boilers and industrial facilities, installing sewage collection systems and holding tanks on naval vessels and constructing pollution control projects ashore to comply with new air and water quality regulations. In the late 1970's, Congress passed new legislation requiring stricter controls and focused on handling and disposal of hazardous waste. Thus, the Navy's program expanded to maintain compliance.

The Navy soon realized that the solution was not the end of the pipe. Changes to basic procedures and processes that produce pollutants in the first place would be necessary. Entire operations, from "cradle-to-grave," now integrate environmental considerations. In many cases this has proven to be a win/win situation. Often, not only is the environment improved, but process changes incorporate new technologies that increase productivity, save energy and improve the safety and health of workers.

Working within the common goal of cleaning up and protecting our environment, the Navy is working hard to convey concerns, in the case of unique operations, to local rulemakers. For example, Navy engineers are working with regulators in California that are writing air emission standards. The objective is to clean up the air using proven, cost-effective technologies while still allowing the use of special coatings for high performance aircraft. Rulemakers are generally reasonable in accommodating unique Defense requirements as long as environmental objectives are also achieved.

Like many large corporations that found it appropriate to involve senior management in environmental issues, the Navy established a Flag Officer Environmental Policy Steering Group to insure that operations are environmentally sound. This group of Navy admirals provides support and oversight at the highest levels in the Navy.

In order to support base commanders, the Navy has established a central network of environmental professionals to provide direct technical support. Environmental staffs at each of the Navy's six regional facilities engineering field divisions provide direct, on-site support for the bases' environmental programs. In addition, centers of expertise have been established to handle Navy-unique aircraft, ordnance and ship environmental issues.

The Navy's research laboratory at Annapolis is developing a special, high volume trash compactor to be used aboard ships to reduce a large volume of trash into a small slug of solid waste that will sink if discharged overboard. The compactor is automatic, simple and safe to operate and easy to maintain.

Environmental Compliance: Air and Water Quality

One of the Navy's success stories is the Air Quality Program. In the early 70's, the Navy began assessing central heating plants and industrial facilities. The Navy modified processes, improved performance, replaced antiquated equipment, added air pollution control devices and trained operators to insure that emission limits were met. The Navy obtained permits and monitored and reported performance. With over 7,000 air sources, the Navy has operated with over 99.5 percent compliance for the last three years. Equipment failures and operator error cause a few violations each year, but these are promptly corrected when they occur.

Perhaps the most significant air quality challenge today is the control of volatile organic compounds. Clean Air Act non-attainment area limitations on volatile organic compound emissions challenged the Navy to find alternative paints in California last year. The Navy responded by developing compliant paints for repair work and by modifying methods. The Navy is working closely with local regulators to develop innovative work processes to allow the Navy to meet mission demands and comply with the total emission limits.

To reduce dependence on foreign oil and to help solve solid waste disposal problems, the Navy has modified several heating plants to allow coal, trash, or even wood chips to be burned instead of oil. To avoid any problem with air quality, electrostatic precipitators were installed as were scrubbers to meet stringent standards. The result is that the Navy has saved money, reduced the amount of waste put into landfills and complied with emission limits.

One of the original thrusts in the Navy Environmental Program was geared toward compliance with the Federal Water Pollution Control Act, now. called the Clean Water Act. Part of this program focused on the elimination of sewage discharge from ships in coastal waters and in America's harbors. Over $150 million in pier sewer connections were installed in Navy ports to accept ships' waste. Likewise, the Navy installed over $500 million worth of internal modifications on ships – putting in sewage collection, holding and transfer systems. All commissioned ships as well as service craft and small boats have been equipped with wastewater systems so that sewage is routinely pumped ashore for proper treatment. The Navy is making similar process in installing oil/water separators aboard ships, and all new ships are constructed so they meet the largest environmental standards. To combat oil spills, the

Navy has purchased over $70 million worth of oil spill cleanup equipment throughout the world, including a fleet of over 40 oil skimmers.

Hazardous Waste Minimization

The Navy has over 150 major installations which produced about 200,000 tons of hazardous waste in 1987. That is about one tenth of one percent of the nation's hazardous wastes. There is no question that hazardous waste minimization is the ultimate solution to hazardous waste disposal problems. Therefore, the Navy has set a goal of 50 percent reduction by the end of 1992. That can be accomplished by continually studying hazardous waste production and looking for improved methods and processes as well as product substitutions.

At the Naval Torpedo Station in Keyport, Washington, chemical paint stripping of torpedoes was replaced with dry plastic media blasting. That change eliminates use of hazardous solvents and 3,500 gallons per week of hazardous wastewater, thus saving over $200,000 each year. In addition, workers are not exposed to hazardous chemicals, energy is saved due to lower ventilation requirements and productivity is increased. This same process will be incorporated throughout the Navy for many other paint stripping operations.

In March 1988, the Governor's Award for Excellence was awarded to the Marine Corps Air Station and the Naval Aviation Depot at Cherry Point, North Carolina, for significant achievement in waste management. Governor Martin made this award based on the Marines' virtual elimination of hazardous wastewater disposal through the use of new electroplating processes and the use of plastic media blasting on 75 percent of their aircraft paint stripping work.

A "model" hazardous materials management program will soon be complete. This model will be used by Navy installations to carefully manage hazardous materials, inform workers of dangers and precautions and seek to eliminate hazardous material during the development of specifications and procurement documents.

The newest challenge, and one which the Navy has as its highest priority, is identifying and cleaning up old waste disposal sites as mandated by the Comprehensive Environmental Response, Compensation and Liabilities Act (CERCLA). The Navy began investigating inactive hazardous waste disposal sites in 1980. This process included interviewing current and former employees concerning their operations and disposal practices and reviewing records and aerial photographs to determine potential hazardous waste disposal sites. The sites identified range from a few square yards to several acres in size.

The Navy has completed preliminary assessments of old waste disposal sites at over 200 Navy installations. As each assessment was completed, the

The Army worked with the State Department, the Environmental Protection Agency and several states' agencies, as well as the public, during the environmental impact analysis process. The EA examined all reasonable alternative methods and sites allowed by the language of the Treaty. The missiles to be destroyed under the INF Treaty that would produce considerable pollutants are the Army's Pershing missiles. The EA analyzed the explosive demolition method, also called "open burn," in which the rocket motor (without electronics, guidance system, or entry vehicle) would be placed in a pit. Then, an explosive would rupture the side of the motor and ignite the propellant which then burns. In another method, "static firing," a rocket motor stripped of electronics and other components would be fastened to a stand. It is then ignited in the same manner as if it were being launched. Several sites at which destruction of the missiles might be conducted were analyzed in the EA.

The Army-developed Geographic Resource Analysis Support System (GRASS) was used to gather relevant data and maps and to facilitate siting analyses. The results were incorporated in the EA. The Army applied certain safety and technological criteria which left them with four sites to consider. The analyses indicated that all sites would be able to sustain the Pershing elimination program without significant environmental impacts. Based on the environmental, safety, technical and economic analyses, the Army is planning to destroy the missiles by "static firing" at Longhorn Army Ammunition Plant, Texas; Pueblo Army Depot Activity, Colorado; and Tooele Army Depot, Utah.

Johnston Atoll Chemical Agent Disposal System (JACADS)

The Army must dispose of certain chemical stockpiles by 1997. The prototype demilitarization process, developed on Johnston Atoll, is called JACADS. Another example of the Army's consideration for the environment during decision making is the environmental impact analysis for JACADS.

The purpose of JACADS is to destroy obsolete and unserviceable chemical agents and munitions stored on Johnston Island, an unincorporated U.S. territory in the central Pacific about 700 nautical miles from Hawaii. The agents and munitions have been stored on Johnston Island since their movement from Okinawa in 1971. Their transport to the United States is prohibited by Public Law 91-672.

The Army recently completed construction of JACADS facilities, and following an initial testing period, full scale operations will begin. JACADS incinerates nerve agents, mustard (a blistering agent) and various explosive components.

The Army prepared an environmental impact statement (EIS) to assess both a demilitarization process and facility location. The final EIS was published in November 1983 and a record of decision (ROD) was made by the end of that year.

The Army deferred the decision on the disposition of the solid and liquid wastes generated by JACADS pending further study of options. The process wastes include incinerator ash, recyclable and unrecyclable metals, pollution abatement system solid residue, refractory solids from the liquid incinerator and scrubber brines. Studies were begun to determine the feasibility of ocean disposal of the process wastes. The Army asked the Environmental Protection Agency (EPA) to designate a deep ocean disposal site for JACADS wastes. The Army proposed a site 13 to 19 nautical miles from Johnston Island and then prepared a draft EIS for the proposed site, released in October 1985. Public comments on the DEIS raised the issues of whether EPA could evaluate the suitability of an ocean disposal site before the Army supplemented its 1983 JACADS EIS to address ultimate process waste disposal options. The Army published the draft supplemental EIS for JACADS process waste disposition in October 1987 and plans to complete the process in 1989.

Electromagnetic Pulse (EMP) Environmental Documentation

The Army's use of the NEPA process in decision making is illustrated also by the environmental analyses being prepared for Army EMP facilities. EMP generators are used by the DOD to simulate effects that pulses created by nuclear explosions may have on electronic and communications equipment. In 1987, questions about the effects on the environment of EMP devices were elevated to Army decisionmakers. Of particular concern are the unknown factors associated with the effects of EMP testing.

The Army took a proactive approach to determine the potential environmental effects of EMP, including potential human health and ecological effects. The environmental analyses that the Army is pursuing are comprehensive and include long term monitoring programs as well as review by agencies or persons with special expertise in EMP and its effects.

Geographic Resources Analysis Support Systems (GRASS)

The management of environmental resources at military installations historically has been a problem due to the wide variations and formats for recorded data. A given installation may have considerable data in a number of different technical areas (wildlife, vegetation, soils, geology, topography). Often, however, it was difficult to assimilate, analyze and present these data in a manner that facilitates routine decision making.

To make environmental information more usable by decision makers, the Army has developed the Geographic Resources Analysis Support Systems (GRASS). GRASS permits the combination of different sources of data (e.g., field surveys, maps, satellite and aircraft imagery) and the multi-criteria report was sent to EPA, state and local agencies. As a result of these preliminary assessments, over 900 sites have been identified for further investigation. The vast majority of the Navy's sites are quite small. This is because most installations are old, located in urban areas and the Navy has disposed of much of its hazardous wastes off the station through private disposal operations. Typical examples of potential hazardous waste disposal sites are spills of small quantities of hazardous substances, solid waste landfills with some hazardous waste and fuel leaks from old tanks.

After the preliminary assessment is completed, the Navy initiates a remedial investigation and feasibility study to verify the presence of contamination at each site. This includes drilling wells, collecting samples and analyzing them. If contamination is confirmed, the study is expanded to measure its extent and evaluate cleanup alternatives. Finally, the site is cleaned up. The Navy consults with EPA, state and local regulatory agencies each step of the way. Meetings are held with the public and questions answered.

The Navy has 13 old hazardous waste disposal sites either listed or proposed on EPA's National Priorities List. These 13 sites have top priority for clean up.

In conclusion, the Navy's active environmental program strives to comply with the nation's environmental laws. Navy personnel have the same concerns for protecting the environment as other members of the community, and are sincerely concerned about the quality of our land, air and water.

Marine Corps and the Environment

Because of the mission of the Marine Corps and the need to maintain capability for amphibious operations worldwide, Marine Corps installations reflect a special character with abundant environmental management challenges.

Amphibious training means that some Marine bases must be located near ocean environments with their fragile estuarine ecosystems. Marine bases in the California desert conscientiously protect and enhance endangered species and archeological sites. Air stations work with their neighbors to prevent incompatible wastes which they treat or dispose. At many installations past waste disposal practices have resulted in sites that must be evaluated and cleaned up under the Department of Defense Installation Restoration Program.

To meet the hazardous waste reduction challenge, the Marines initiated waste minimization studies at the greatest generators, the Marine Corps Logistics Bases at Albany, Georgia and Barstow, California. At Barstow, they are working with the State of California to cleanup hazardous waste sites. Remedial designs are complete and may be the first remedial actions of their scale undertaken by the Department of Navy.

The Marine Corps Air Station at El Toro, California, has a model recycling program that can serve as a prototype program for all Marine Corps installations.

The Marine Corps Air Station at Cherry Point, North Carolina, contains the Naval Aviation Depot which presents some formidable environmental challenges. The base has responded by developing an award-winning environmental protection program. In March 1988 the Governor's Award for Excellence was presented to the Marine Corps Air Station and the Naval Aviation Depot for significant achievements in waste management. Governor Martin presented the award based upon the virtual elimination of hazardous wastewater through the use of new electroplating processes and the use of plastic media blasting on 75 percent of their aircraft stripping work.

The Air Force and Environmental Protection

The Air Force operates 9,500 aircraft from over 100 major installations in the United States. These are small cities, ranging in population from 4,000 to 20,000. Air Force installations are among the largest population communities in some states and the five main maintenance facilities are the major employers in their areas.

The Air Force has a longstanding commitment to environmental quality. Initially, this was a matter of protecting the well-being of the military. That meant making sure that liquid and solid wastes were properly collected, treated and disposed of and that groundwater protection was an integral part of all siting considerations. Today the protection of the environment has a much broader scope and is an integral part of the mission.

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Pollution Abatement and Control

The increasing environmental awareness of the 1970's beginning with NEPA, sent a clear message to the nation. The Air Force also realized that an organization with capabilities in the various technical, economic and social disciplines was needed. Thus the Air Force Environmental Division was formed with responsibilities for development and oversight of multi-media pollution prevention, control and abatement programs, natural resources programs, environmental and base comprehensive planning, the Air Installation Compatible Use Zone Program and the Air Force Installation Restoration Program. But, in total, the Air Force has a dedicated environmental quality force of over 800 full time military and civilian professionals. These are augmented by another thousand who spend some time on environmental matters. Additionally, almost 1,500 people operate and maintain pollution control facilities.

Since its inception as the Army Air Service, the Air Force has recognized that pollution control and abatement was important. Initially programs were established to protect the health and safety of employees. The environmental program has evolved to not only protect and enhance the quality of the environment for Air Force employees, but also to manage the mission in a manner that is sensitive to the surrounding community and the complexities of the environment and natural resources.

The beginning of the Air Force's environmental program of today has a long history of protecting water quality. The first biological treatment system to be installed anywhere in DOD went into operation at Randolph Field, Texas, during World War I. Passage of the 1965 Clean Water Act brought added emphasis to this program.

The Air Force also aggressively pursued air pollution control – both from fixed facilities and aircraft engines. Initial control methods for stationary sources focused on conversion from old coal-burning plants to cleaner fuels, such as oil and natural gas. The energy crisis of the mid 70's caused reevaluation of "simple" solutions and renewed emphasis on treatment to reduce emissions while burning available coal supplies. Particulate emissions have been reduced, so efforts now concentrate on volatile organic compounds (VOC) emission control. The Air Force is focusing on reduction of emissions from fuel storage facilities which make up half of the VOCs from Air Force sources.

Together with the Federal Aviation Administration and NASA, the Air Force has actively pursued the development and installation of a smokeless combustor for aircraft – a problem compounded by the necessity to maintain combat performance ability. The Air Force prefers aircraft which do not trail smoke or any other exhaust signature. Thus, an Air Force requirement for Low visibility exhaust and environmental protection come together in a common need for improved aircraft engines.

Hazardous Waste Minimization

Building on initial efforts in water and air pollution control, the Air Force focus today is on control at point of generation. Thus waste cleanup and minimization are receiving a lot of attention. Past practices for disposal of hazardous wastes, while accepted at the time, have been shown to be potential threats to the environment and public health. The Air Force Installation Restoration Program (IRP) addresses these problems. Initiated in 1979, the IRP includes finding, assessing and cleaning up waste disposal sites which pose a threat to the environment or health. While the program was initiated in 1979, passage of special appropriations legislation in 1984 for a Defense Environmental Restoration Account (DERA) thrust IRP into the forefront of environmental issues as an analog to the Superfund. All major installations have been assessed to determine if cleanup is required and further investigations are under way at 96 bases. Since 1980, removals or other remedial actions have been undertaken at 44 bases. DERA funds are also used to fund IRP technology research and a share of cleanup costs at sites off bases which received Air Force wastes. To date, the Air Force has spent over half a billion dollars to study the problem and clean up bases. Through the end of the century, almost four billion dollars may be required to finish the job.

Federal and state environmental regulatory agencies regularly inspect Air Force installations for compliance with environmental regulations. To improve environmental compliance, the Air Force established the Environmental Compliance Assessment and Management Program (ECAMP), a self-auditing program. The objective of ECAMP is to enhance environmental compliance through the use of compliance evaluations and management action plans. This approach allows installation commanders to identify the compliance issues, correct the immediate problems and program the resources needed for the longer term and expensive efforts.

Initiated in 1987, the Air Force Radon Assessment and Mitigation Program (RAMP), was prompted by results of commercial radon testing throughout the United States and concern for public health. During the initial assessment phase, 4,040 indoor air samples were taken in housing units, schools, child care centers and dormitories at 135 major Air Force installations worldwide. Of these, over 95 percent had radon levels below the EPA mitigation levels. The bases identified by this initial screening process will be entered into the detailed assessment phase to identify all Air Force structures requiring mitigation.

Land Use Planning

The Air Installation Compatible Use Zone (AICUZ) program promotes compatible land use around military airfields. The goal is to protect both the public

Appendix A

Report on the Activities of the Council on Environmental Quality During 1987 and 1988

The Council on Environmental Quality (CEQ) was established by the National Environmental Policy Act (NEPA) which was signed into law on January 1, 1970. The Council consists of three Members, appointed by the President and confirmed by the Senate. The Council, through the Chairman, provides advice to the President on environmental matters, prepares the President's annual Environmental Quality Report, and assists federal agencies in the implementation of NEPA.

A. Alan Hill has served as Chairman of CEQ since 1981. Member William L. Mills, Ph.D., was appointed in 1983, and Member Jacqueline E. Schafer in 1984.

Office of the Chairman

Chairman Hill participates in meetings of the President's Domestic Policy Council when environmental matters are being discussed. For example, during 1987-1988, the Chairman met with the Domestic Policy Council concerning the Convention on Long Range Transboundary Air Pollution, international negotiations on a protocol to reduce stratospheric ozone depletion, persistent marine debris, outdoor recreation, and implementation of recommendations of the Special Envoys on Acid Rain.

Chairman Hill also represents the President at formal national and international meetings concerned with environmental issues.

As the presidential advisor on the environment, Chairman Hill is actively involved in preparing and commenting on drafts of environmental messages, executive orders, and decision memoranda. To enable him to provide practical and informed advice to the President, the Chairman meets frequently with representatives of science, industry, agriculture, labor, conservation organizations, state and local governments, and other groups.

The CEQ Chairman serves as a joint chairman of the Interagency Toxic Substances Data Committee (ITSDC), a part of the Interagency Testing Committee (ITC) which was established under the Toxic Substances Control Act. The ITSDC was established to improve coordination in the generation, sharing, and management of information about chemical substance life cycles and effects upon the environment.

The agency is also a statutory member of the ITC which is charged with recommending to the EPA Administrator those chemical substances which should be given priority consideration for promulgating health and environmental testing rules. CEQ representatives attend the meetings of these two committees on a regular basis.

The Chairman also directs the work of the Council and the Office of Environmental Quality, which provides support staff for the Council.

In 1987 and 1988, Chairman Hill continued to coordinate federal agency activities concerning the World Commission on Environment and Development (WCED), an independent body composed of prominent individuals in the environmental field from around the world. The WCED was mandated by the United Nations to propose alternative strategies for environmentally-sound, long-term global development. These strategies were put forward by the WCED in a report which was issued in April, 1987.

The Council coordinated the formulation of a United States' policy statement on the WCED Report, as well as the United States' negotiating effort with regard to the Report. The WCED Report was discussed at the 14th Session of the Governing Council of the United Nations Environment Programme in June, 1987, and in the United Nations General Assembly in October, 1987. The Chairman of CEQ headed the United States' delegation at the Governing Council Session, and presented the United States' response to the WCED Report in the General Assembly.

In addition to its WCED activities, the Council, through Chairman Hill, continued to coordinate the development of a long-term strategy for environmental protection and rational use of natural resources in countries which are members of the United Nations' Economic Commission for Europe (ECE), and participated in a meeting of ECE representatives in Geneva, Switzerland which considered a draft framework agreement for transboundary environmental impact assessment. The Council also continued to work with the United Nations Environment Programme on issues relating to global warming, species preservation, regional seas, and environmental impact assessment.

Under the guidance of the Chairman, the Council continued its oversight of the work of the International Whaling Commission in 1987 and 1988. CEQ participated in an interagency committee to oversee implementation of the moratorium on commercial whaling which went into effect in 1986. Several nations have continued to object to the moratorium, and the United States has, in some instances, imposed economic sanctions on such countries.

Council Members

The two Council Members are responsible for specific projects and studies, in addition to representing CEQ on interagency committees and task forces.

Dr. Mills has primary responsibility for the Council's Management Fund. The Management Fund is used for interagency environmental studies and projects. CEQ initiates or co-sponsors conferences, studies, surveys, analyses, publications, and research pertaining to current environmental issues. This work, which is performed under contract, is financed directly from the Management Fund to which funds are contributed by various agencies with environmental responsibilities.

Dr. Mills is responsible for assessing project proposals from other federal agencies, and for reviewing contracts initiated through the Fund, quality control, schedule monitoring, budget control, and payment certification. He also serves as the Council's liaison between the Office of Administration in the Executive Office of the President and potential contractors.

Dr. Mills is also the Council's representative on the sub-Cabinet Working Group on Biotechnology, an interagency body which provides guidance on the adequacy of federal laws and regulations to protect public health and the environment from possible hazards associated with the products and processes of biotechnology.

In addition to these activities, Dr. Mills has been delegated responsibility for participation on the ITC and ITSDC by Chairman Hill. Further, in 1987 Dr. Mills worked with state and local governments on asbestos abatement, with the National Transportation Safety Board on the transport of hazardous materials, and with the District of Columbia School Board on technology and the environment. In 1988, Dr. Mills also served on the Marine Pollution Control Board of the National Oceanic and Atmospheric Administration, and traveled to Mexico to meet with officials of the Mexican government and representatives of ecology groups to discuss air pollution and urban congestion.

Council Member Schafer is responsible for overseeing the internal management of the activities and expenditures of the Office of the Director of the National Acid Precipitation Assessment Program (NAPAP), the research program of the Interagency Task Force on Acid Precipitation (ITFAP). The goal of NAPAP is to develop and improve on an objective and comprehensive scientific and technical information base for use by decisionmakers. CEQ was designated by the White House to serve as Executive Secretary to the ITFAP; Member Schafer serves in this capacity. From October 1987 to March 1988, Miss Schafer was also designated Acting Director of Research for NAPAP, pending the selection of a successor to the former Director. The Office of the Director sponsors studies, peer reviews, and meetings involving both the national and international community concerned with the problem of acid precipitation, and staffs the ITFAP.

Council Member Schafer participates in the deliberations of the Domestic Policy Council's Working Group on Energy, Natural Resources, and Environment. In this role, she assists in the review of policy issues and in the preparation of briefing papers for the Domestic Policy Council. Since August 1987, Member Schafer has served as Chairman of the Domestic Policy Council's Task Force on Outdoor Recreation Resources and Opportunities. This Task Force conducted a major analysis of the Reagan Administration's recreation policy and prepared proposals for the President. The Task Force report, *Outdoor Recreation in a Nation of Communities: Action Plan for Americans Outdoors*, was released in June 1988, and printed for general distribution in July 1988.

In 1987 and 1988, Miss Schafer also directed preparation of chapters for *Environmental Quality 1986*, which was released on October 3, 1988; and *Environmental Quality 1987-1988*, the current CEQ annual report.

Office of Environmental Quality

The Environmental Quality Improvement Act of 1970 established the Office of Environmental Quality (OEQ) to provide staff support for the Council. The Chairman of CEQ serves as the Director of OEQ. CEQ also relies upon professional staff temporarily assigned from other federal agencies. In 1987 and 1988, the staff of the Office included the following individuals:

Julia Alessio	*Paralegal Specialist (through 8/87)*
Dinah Bear	*General Counsel*
Kurt Christensen	*Staff Scientist (beginning 6/87 through 12/87)*
Susan M. Cohen	*Executive Assistant to the Chairman*
John J. Cohrssen	*Attorney Advisor*
Donna Clark Connell	*Program Analyst (through 5/87)*
Carroll N. Curtis	*Environmental Quality Specialist (detail) (through 9/87)*
Lisa D. Defensor	*Staff Attorney (beginning 5/87 through 7/88)*
John Elliot (detail)	*Annual Report Editor (through 3/87)*
Kathleen Gallagher	*Confidential Assistant (beginning 6/87)*
Joseph P. Jehl	*Senior Scientist (beginning 7/87 through 3/88)*
John Michos	*Legal Intern (through 6/87)*
Lynne Grant Mohr	*Administrative Specialist*
Sara Dumke Nero	*Confidential Assistant*
Coleman Nee	*Special Assistant to the Chairman for International Affairs (through 1/88) (detail)*
Kevin Omland	*Intern (Summer 1987)*
Todd A. Ornett	*Intern (Summer 1987)*
Steven Russell	*Intern (Summer 1987)*
Lucinda Low Swartz	*Deputy General Counsel*
Edward E. Yates	*Staff Attorney (beginning 7/87)*

NEPA Oversight

Throughout 1987 and 1988, the Council continued to fulfill its responsibilities with regard to the implementation and administration of the federal environmental impact analysis process. CEQ's activities in this area during this period are discussed in Appendix B of this report.

Environmental Policy Development Studies and Projects

In 1987 and 1988, CEQ continued its preparation of the second *Environmental Trends* report. This effort, begun in 1984, is being conducted and funded by approximately 15 federal agencies with environmental responsibilities; the Council has the central coordinating role in developing the report. Through the use of maps and charts, the report is designed to portray quantitatively the current conditions and trends in the quality of the environment.

The first *Environmental Trends* report was published in 1981. The revision of the report at five-year intervals was deemed to be a meaningful time period in which to assess discernible trends in the environment. The second report is scheduled for completion and publication early in 1989.

Publications

■ **Environmental Quality 1985**, the 16th annual report of the Council on Environmental Quality was released on July 16, 1987.

It features an historical review and analysis of the management and use of the nation's forests, grasslands and croplands from pre-colonial times to the present day; over half the report consists of a comprehensive review of international environmental issues.

■ **Environmental Quality 1986**, the 17th annual report of the Council on Environmental Quality, was released on October 3, 1988. This report includes a 136-page statistical appendix presenting *Environmental Trends* data through 1986 in tabular form.

■ **Outdoor Recreation in a Nation of Communities: Action Plan for Americans Outdoors**, the report of the Domestic Policy Council's Task Force on Outdoor Recreation Resources and Opportunities, was printed in July 1988. CEQ chaired the Task Force and directed the preparation of the report.

These reports are available for sale by the Superintendent of Documents.

and the flying mission of the installation from the negative effects of incompatible off-base development. Since its inception in 1973, the Air Force's AICUZ program has been a model for similar programs implemented by the other military services and the FAA. To date, 90 Air Force installations have prepared and distributed AICUZ studies in an effort to supply local governments information on the noise and safety considerations associated with aircraft operations. Land use compatibility guidelines based on these considerations are also provided to the communities for use in their land use planning and zoning process. Where AICUZ recommendations have been adopted, both the public's quality of life and the installation's operational integrity have been enhanced.

The Base Comprehensive Planning (BCP) Program strives to develop new concepts for base utilization and quality of life into the 21st century. The objective of BCP in the Air Force is to build a comprehensive framework for many separate but interrelated programs in order to provide an overall, long range plan to effectively manage the installation's natural, constructed and human resources. It is the primary means to assess the effects of operational changes on an installation's natural resources and support systems in order to guide development into the 21st century. Comprehensive planning is a process in which very early programming and design decisions are made to provide the foundation for sound community development.

Environmental Challenges Ahead

The foregoing review of each of the military departments reveals a set of concerns common to all the services, which emerge as the most challenging environmental problems facing the Department of Defense. The Department appears to be fully aware of enormous task it faces and prepared to be diligent in solving these problems in creative and effective ways. In summary, these challenges include:

- Acquiring and maintaining access to sufficient land and airspace to accomplish defense missions
- Integrating environmental considerations into the complex defense systems development and acquisition process
- Effectively managing hazardous materials, and minimizing the generation of hazardous wastes
- Cleaning up past waste disposal sites that pose a threat to public health or environmental quality.

Caring for the environment is a mission of the military of which most citizens are unaware. Yet billions of their tax dollars have been spent through the Defense budget over the past 25 years to provide environmental protection and restoration. This commitment will continue to be reflected in the way the Defense Department does business. Proper management of natural resources on the nation's Defense lands and installations provides many benefits, both to the Department and the public. For the Department of Defense not only maintains facilities and training areas for present and future use, but demonstrates to the American people that a military installation can be a good neighbor and a good guest.

Appendix B

The National Environmental Policy Act

Highlights of 1987 and 1988

During 1987, CEQ co-sponsored a conference on preparation and review of environmental impact statements at both the federal and state level. Held in West Point, New York, the conference was the first comprehensive, national examination of this topic since CEQ promulgated the regulations implementing the procedural provisions of the National Environmental Policy Act (NEPA) in 1978. A special feature of this appendix is a compendium of legal authorities, significant cases, and state contacts for state environmental impact assessment laws (state "little NEPA's"), which was developed as part of the 1987 conference at West Point, New York.[1]

In 1987, CEQ issued Findings and Recommendations on the referral by the U.S. Environmental Protection Agency of proposed amendments to the U.S. Army Corps of Engineers' NEPA procedures. CEQ has also initiated a comprehensive survey on compliance with Executive Order 12114, covering Environmental Effects of Federal Actions abroad. During 1988, CEQ issued Findings and Recommendations on a referral by the Department of the Interior regarding proposed overflights by the Department of the Navy impacting the Cape Lookout National Seashore in North Carolina. Other activities related to NEPA throughout this period included emergency relief actions, participation in international environmental impact assessment activities, and advice concerning NEPA responsibilities for particular proposed actions.

Some of the significant appellate and district court decisions dealing with NEPA issues during 1987 and 1988 are discussed below, including two cases that were subsequently heard in the Supreme Court of the United States during the 1988-89 term (*Oregon Natural Resources Defense Council* v. *Marsh and Methow Valley Citizens Council* v. *Regional Forester*). Both of these cases deal with the issues of worst case analysis and mitigation. Other significant cases dealt with the appropriate timing for NEPA review of oil and gas leasing on public lands, and the analysis of cumulative effects of proposed actions.

The annual CEQ survey of NEPA litigation showed a continuation of the trend in the number of NEPA lawsuits filed against federal agencies (1986 – 83 cases; 1987 – 80 cases). The discussion is supplemented with charts showing the breakdown of lawsuits by federal agency, type of plaintiff, and type of complaint. Additionally, there is a chart reflecting cumulative totals from the past seventeen years of NEPA litigation.

CEQ and the NEPA Regulations: 1987 and 1988 Activities

CEQ promulgates and interprets the regulations implementing the procedural provisions of the National Environmental Policy Act. Those regulations are binding on all federal agencies in the executive branch of government. 40 C.F.R. 1500-1508 (1987). During 1987, CEQ continued to fulfill its responsibilities related to these regulations. These activities include: informal consultation with federal agencies regarding appropriate implementation of NEPA procedures; approval of federal agency NEPA procedures and amendments to those procedures; informal consultation with state and local governments and private citizens regarding NEPA procedures; commenting on proposed legislation and testimony which is related to NEPA; designating lead agencies for the purpose of preparing environmental impact statements (EIS); making determinations on requests for emergency exemptions and alternative procedures for supplemental EIS(s); handling formal referrals to CEQ of major federal activities; participating in international activities related to environmental impact assessment; and disseminating information about the NEPA process to interested parties.

During 1987, CEQ:

■ **Issued Findings and Recommendations of the Council** regarding the Referral of Proposed Amendments to the Army Corps of Engineers' NEPA Procedures. The CEQ NEPA regulations include procedures for referring to CEQ federal interagency disagreements concerning proposed major federal actions that might cause unsatisfactory environmental effects. *See* 40 C.F.R. Part 1504. Under these provisions, the Environmental Protection Agency (EPA), referred to CEQ proposed amendments to the Army Corps of Engineers' NEPA procedures. After extensive study of the proposed amendments, including participation from interested agencies and members of the public, CEQ issued Findings and Recommendations which addressed the four issues raised in the referral; specifically:

- **Scope of analysis:** "The Army's current regulation addressing the scope of analysis can 'federalize' private or state or local projects over which, absent one Army permit, the federal government has neither control nor responsibility. CEQ finds that Army's proposal to amend this regulation is generally within reasonable implementing agency discretion and that policy and management considerations favor amending the regulation to provide formal and consistent guidance to Corps field personnel.

However, CEQ offers comments and recommendations to improve the usefulness of the . . . guidance to District Engineers charged with determining the scope of analysis."

- **Purpose and Need:** "CEQ finds that the proposed regulation is generally adequate, but recommends that additional language be inserted in the amendment to the effect that the agency must, in all cases, exercise independent judgment regarding the public purpose and need for the proposal."
- **Analysis of Alternatives in Environmental Assessment:** "There is no legal requirement to include a specific reference to 'water dependent activities' under the Section 404(b)(1) guidelines in the Army's NEPA procedures. However, CEQ recommends that in the spirit of consistency with the CEQ regulations and as sound management policy, specifically to reduce duplication and paperwork and to increase efficient compliance with both NEPA and the Clean Water Act, the Army procedures retain the requirement to integrate into the environmental impact analysis the alternatives to non-water dependent activities under Section 404(b)(1)."
- **Page Limits on Environmental Impact Statements:** "CEQ finds that the Army's proposed regulation to be premature in that the Army has not presented any evidence demonstrating that there has been a conscious effort to abide by the CEQ page limit recommendations. CEQ recommends that the Army attempt concerted compliance with the CEQ regulation [40 C.F.R. 1502.7] before proposing a reduced page limit." *Recommendations of the Council on Environmental Quality regarding the proposed amendments to the Army Corps of Engineers' Procedures Implementing the National Environmental Policy Act*, 52 *Federal Register* 22517, June 12, 1987.

■ **Co-sponsored (with the Environmental Law Section of the New York State Bar) and participated in a Conference on Preparation and Review of Environmental Impact Statements**, at West Point, New York, November 17-18. This national conference brought together representatives of the federal government and state and local agencies from all parts of the United States, as well as representatives from Canada. The conference sessions were organized around the themes of comparative federal and state environmental impact statement processes and procedures, technical analysis and contents of EIS(s) and uses of EIS(s).

■ **Initiated a comprehensive survey of federal agency compliance with Executive Order 12114**, covering Environmental Effects of Federal Actions Abroad.

- **Held Sunshine Act meetings** on atmospheric issues, terrestrial impacts, and human health impacts of ozone depletion and the greenhouse effect.

- **Worked extensively with staff of the Federal Energy Regulatory Commission** (FERC), culminating in approval of the first FERC NEPA procedures to adopt the CEQ regulations.

- **Participated in proceedings** of the Administrative Conference of the United States as a Liaison Member (Committee on Administration).

- **Granted emergency relief under the NEPA regulations** to the U.S. Fish and Wildlife Service for destruction of five million juvenile upright bright fall chinook salmon in Skamania County, Washington, which were diagnosed as having infectious hematopoietic necrosis. The virus causes potentially uncontrollable losses in trout and salmon.

- **Contributed to** and vigorously supported formulation and passage of Principles and Guidelines for Environmental Impact Assessment for United Nations Environment Programme.

- **Led American delegation** at second meeting of environmental impact assessment project in Japan, under the US-Japan Environmental Agreement.

- **Met with representatives** of the Animal and Plant Health Inspection Service, EPA, and members of the environment community to discuss appropriate NEPA compliance for the Animal Damage Control program.

- **Led the American delegation to Economic Commission for Europe** (ECE) seminar on environmental impact assessment.

- **Met with and advised numerous federal agencies** on NEPA responsibilities for specific proposed actions.

During 1988, CEQ:

- **Issued Findings and Recommendations of the Council** regarding the Referral of Proposed Overflights by the Department of the Navy Impacting the Cape Lookout National Seashore, North Carolina. In December, 1987, the Department of the Interior referred to CEQ a proposal by the Department of the Navy (United States Marine Corps) to establish the Cherry I and Core Military Operating Areas (MOA) at Cherry Point, North Carolina. The primary issue raised in the referral was the potential noise impact on the Cape Lookout National Seashore which is managed by the National Park Service. The CEQ held a public meeting in January, 1988, and provided an opportunity for written comments to be submitted for the CEQ's consideration. The CEQ Chairman and staff conducted a site visit and held additional meetings in the area in May, 1988. By letter dated September 13, 1988, CEQ made several findings and recommendations. Specifically:

- **Alternatives:** CEQ was unable to conclude that there were any reasonable alternatives available to the Marine Corps for its low altitude, high speed training flights. Thus, CEQ stated that the National Park Service and the Marine Corps should work together to mitigate the expected noise impacts on the seashore. As part of this resolution, the Marine Corps should undertake environmental monitoring studies which examine the actual impacts of the overflights on the park.

- **Cumulative effects:** CEQ found that the cumulative effects of military airspace use over North Carolina had not been adequately considered, and that the Federal Aviation Administration (FAA), the agency which will give final authority for the overflights, must prepare a cumulative impact analysis as part of its NEPA documentation for the Cherry I and Core MOA designation request.

- **Agency coordination:** CEQ found a need for coordination within the Department of Defense to adequately assess the cumulative impacts of the military agencies' airspace use requests, and a need for consideration of the inherent conflicts between airspace use and land use below. CEQ also found that the FAA needs to play a larger role in the assessment of competing uses and of cumulative impacts of all its airspace designation decisions. *Findings and Recommendations by the Council on Environmental Quality Regarding the Establishment of the Cherry I and Core Military Operating Areas Over Cape Lookout National Seashore, North Carolina*, 53 *Federal Register* 36357, September 19, 1988.

■ **Reviewed and approved revisions to NEPA procedures** for the Farmers Home Administration, the Department of Housing and Urban Development, and the Department of the Army. The Department of the Army revisions included important changes related to implementation of NEPA and the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA, or Superfund); mitigation and monitoring responsibilities, and categorical exclusions. In addition to the formal consultations and approvals given by CEQ, CEQ worked with the Department of the Navy, the Department of the Air Force, the Forest Service, the Federal Aviation Administration, the Federal Communications Commission and the Nuclear Regulatory Commission to develop or revise those agencies' NEPA regulations.

■ **Authorized an emergency exemption for the issuance of a license** for a hydroelectric facility at the Milner Dam on the Snake River, Idaho, to permit repairs to be made to the dam. The dam was in danger of failing, which would have caused loss of irrigation to approximately 440,000 acres of farmland and possible loss of life.

■ **Met with numerous federal agencies**, including the National Aeronautic and Space Administration, the Minerals Management Service, the National Institutes of Health, the Farmers Home Administration, the Rural Electrification Administration, the Food and Drug Administration, and the National Science Foundation, to review general NEPA compliance issues.

■ **Testified before the Secretary of Defense's Commission** on Base Realignment and Closure on the subject of how environmental impacts should be considered in base closure recommendations.

■ **Consulted with federal agencies and private organizations** regarding the National Science Foundation's activities in the Antarctica, in relation to compliance with NEPA and Executive Order 12114, Environmental Effects of Major Federal Actions Abroad.

■ **Advised the Federal Highway Administration** on a proposed "tiering" approach to NEPA compliance for a proposed bypass highway for the greater metropolitan Washington, D.C. area.

■ **Consulted with the Federal Aviation Administration** concerning the NEPA documentation for airports in New Hampshire and North Carolina and for a flight plan modification over New Jersey.

■ **Advised the National Oceanic and Atmospheric Administration** on compliance with NEPA with respect to that agency's obligations to implement the Marine Mammal Protection Act Amendments of 1988.

■ **Attended a meeting of experts of the Economic Commission for Europe** to consider a draft framework agreement for environmental impact assessment in a transboundary context.

■ **Attended a Joint Committee Meeting** under the auspices of the US-USSR Agreement on Cooperation in the Field of Environmental Protection, and conducted the eighth project meeting of Area XI under that Agreement, Legal and Administrative Measures for the Protection of the Environment.

NEPA Litigation – 1987

United States Supreme Court

No cases concerning NEPA were heard by the United States Supreme Court in 1987.

United States Courts Of Appeals: Selected Decisions

■ *Oregon Natural Resources Defense Council* v. *Marsh*, 820 F.2d 1051 (9th Cir. 1987). *Methow Valley Citizens Council* v. *Regional Forester*, 833 F.2d 810 (9th Cir. 1987).

The issues of mitigation and "worst case" analysis were presented in two similarly decided cases in the Court of Appeals for the 9th Circuit. In *Oregon Natural Resources Defense Council* v. *Marsh* (*Marsh*),[2] the court enjoined the Corps of Engineers from construction of the Elk Creek Dam in Oregon because of the inadequacy of the final Supplemental EIS (SEIS). The Elk Creek Dam was part of a larger Rogue River basin hydroelectric project in which two dams had previously been constructed.[3] Plaintiffs contended that the SEIS for the Elk Creek Dam was inadequate because the mitigation plan for wildlife contained neither a detailed analysis of mitigation measures nor an explanation of how effective those measures would be. Plaintiffs, citing conflicting results from the studies on the two previous dams, also asserted that the SEIS was inadequate because information concerning turbidity was unknown at the time of the drafting of the document and that therefore a "worst case" analysis was necessary.

In *Methow Valley Citizens Council* v. *Regional Forester*,[4] the Court ruled that the environmental impact statement drafted in response to the application for a special use permit to develop an alpine ski resort in Central Washington was inadequate. Plaintiffs argued that mitigation measures to reduce new sources of air pollution were not sufficiently detailed. Plaintiffs had also alleged that the ski resort would bring increased development to the adjacent area, an important migration route for mule deer, and that as the Forest Service did not have the necessary information concerning the mule deer, a worst case analysis should have been included in the EIS.

In each case, the plaintiff alleged that the final EIS was deficient in that it failed to adequately "develop" a mitigation plan which should include technical data and analysis. The court agreed, and in reversing the lower court decisions, determined that measures to compensate for wildlife loss upon construction of Elk Creek Dam in *Marsh* and measures to reduce on-site pollution from the proposed ski facility in *Methow Valley* had not been sufficiently developed at the completion of the EIS's. Citing a CEQ regulation, 40 C.F.R. §1502.16(h), the Court stated in *Marsh* that, "An EIS must include a discussion of measures to mitigate adverse environmental impacts of the proposed action. . . . We fail to see how mitigation measures can be properly discussing the impacts of the entire transit system. The rail system plans had been curtailed indefinitely due to federal budget cuts but federal funds were still available for the MOS-1 segment and the county was still proposing the construction of that segment. The plaintiffs had not challenged the adequacy of the environmental assessment concerning the MOS-1 segment but did assert that it was part of a larger project which could not be separated from the whole.

The court however held that the rule against segmentation should not be applied in every situation and the MOS-1 project could be separated from the overall plans for a regional transit system because, "MOS-1 is an independent project that would make a much needed contribution to Los Angeles' transit system."[23] The court gave a four part test to determine the scope of the EIS in such situations. Included in the test is whether the proposed segment, "(1) has a logical termini; (2) has substantial independent utility; (3) does not foreclose the opportunity to consider alternatives, and (4) does not irretrievably commit federal funds."[24] The court decided that the project indeed met the test and ruled that on its own the MOS-1 project was a viable project with logical endpoints that allowed it to be assessed separately from the larger transit plan.

The *Taxpayer* factual situation is distinguishable from that in *Gilchrist* in that the MOS-1 system met the first two parts of the test a logical termini and substantial independent utility and the highway in *Gilchrist* clearly did not. The segments of the highway constructed by the county in *Gilchrist,* could not have had independent utility or a logical termini *unless* they connected passing through the park whereas MOS-1 did have an independent utility and did not need any connecting portions or future federal decisions to be useful on its own. The judge in *Taxpayer* expanded the test further by balancing the need for flexibility in important local planning decisions against the environmental impacts that the immediate project would cause: here the MOS-1 portion made a much needed contribution to a city that was facing a "debilitating deadly gridlock" and plaintiffs had not objected to the environmental review of MOS-1. The court, which had earlier stated that the segmentation doctrine should not be applied in every situation, concluded that Los Angeles' official's need for flexibility in their attempts to alleviate their huge transportation problems was one such situation where segmentation should *not* be applied.

But the *Taxpayers* decision, unlike *Gilchrist,* did not include a discussion of the applicability of the CEQ regulation, which states that no actions should be taken that would limit the choices of alternatives that are available to federal officials.[25] The *Taxpayer* court therefore, did not address the point that so clearly troubled the *Gilchrist* court; whether a federal decision maker's options would be diminished or his judgment influenced if part of a transportation system had already been funded.

■ *Foundation on Economic Trends* v. *Lyng*, 817 F.2d 882 (C.A. D.C. 1987).

The necessity for the preparation of programmatic EIS' were discussed in *Foundation on Economic Trends* v. *Lyng.*[26] In *Foundation*, the plaintiffs asserted that the U.S. Department of Agriculture's animal productivity research constitutes a "major federal action" under NEPA because the research is directed toward a single policy objective.[27] In asserting that a programmatic EIS was necessary plaintiffs relied on CEQ's regulation, 40 C.F.R. §1508.18(b)(3) which states that the adoption of programs, such as "a group of concerted actions to implement a specific policy" constitutes a federal action.

The court however, rejected the plaintiff's interpretation, stating that, "mere commonality of objective is insufficient under the guidelines to constitute a major federal action."[28] The court explained that for a series of actions to be defined as a major federal action, CEQ regulations 40 C.F.R. 1502.4(a) and 1508.25(a)(1) require more than just a common, underlying policy: the agency's projects or decisions must be "concerted" or "systematic and connected."[29] The court stated that, under §1508.25(a)(1), separate projects could be considered sufficiently concerted or connected to make up a program or action, if they;

> "(i) Automatically trigger other actions which may require environmental impact statement." (ii) "Cannot or will not proceed unless other actions are taken previously or simultaneously." (iii) "Are interdependent parts of a larger action and depend on the larger action for their justification."[30]
>
> Based on these factors, the court decided that USDA research projects with rudimentary similarities do not suffice "to bind into a program" simply because they all have the common goal of increasing animal productivity. The court also emphasized that EIS requirements are triggered by concrete proposals for action and held that the objectives of scientific research, specifically, the objectives of USDA's scientific research, are not "proposals for action."

The court's decision was partly based on its overall concern that NEPA litigation not be used for resolving fundamental political disputes, such as whether animal research projects cause unacceptable health hazards. The court was troubled by the generality of the plaintiff's complaint which did not cite any complaints about specific projects but only referred to the connection between USDA's research goals and increases in animal disease, and the dangerous use of antibiotics.[31]

■ *Ringsred* v.*City of Duluth*, 828 F.2d 1305 (8th Cir. 1987).

The 8th Circuit addressed the issue of whether a very small federal act which is part of a much bigger non-federal project can be used as a "handle" to bring the action under NEPA.[32] In *Ringsred* v. *Duluth*,[33] an Indian Tribe had leased property held in trust by the Secretary of Interior to be renovated and used as a gaming facility. After preparing an environmental assessment on the renovation activities the Department of Interior approved the lease. As part of the overall agreement with the Indian tribe, the City of Duluth had agreed to construct a parking ramp for the gaming facility. Plaintiffs had contended that as the lease approval was part of a larger project, then the Department of Interior was required to assess the environmental impact of the parking facility.

The court disagreed, concluding that the Secretary's approval of the lease relating to the City's parking ramp project did not transform the project into part of a major federal action whose environmental effects should have been reviewed under NEPA. The court noted that the Secretary did have factual veto power relating to the parking ramp but then explained that this veto power did not signify enough to make the project a major federal action. The court set out three factors to consider in deciding whether a "small federal handle" can turn an essentially private or non-federal project into a federal one for purposes of NEPA:

> "(1) the degree of discretion exercised by the agency over the federal portion of the project; (2) whether the federal government has given any direct financial aid to the project; and (3) whether the overall federal involvement with the project [is] sufficient to turn an essentially private action into federal action."[34]
>
> Here, since the federal government "has no input regarding the design or construction of the ramp" and supplied no financial aid to the project nor did it receive any revenue from it, the federal government's activity was deemed insufficient to term the entire gaming and parking facility a federal project. The court pointed out that the city itself could have constructed the parking lot without federal approval indicating that the project did not depend on the federal government approval which would have given plaintiffs the "small federal handle."

The court, in addressing a closely related matter, also determined that the original environmental assessment need not have considered the parking ramp as a secondary or indirect impact of the proposed sub-lease approval for the gaming facility as the parking ramp was only in proposal stage at that time. The court was concerned that if federal agencies had to speculate as to the environmental impacts of privately proposed developments that are outside the control of the federal government, the burden on federal agencies under NEPA might double.

District Courts: Selected Decisions

■ *Alabamians For A Clean Environment* v. *EPA*, 26 ERC 2117 (D.C. N. Alabama 1987).

In one of a series of cases excusing some of the Environmental Protection Agency's (EPA) programs from compliance with NEPA, an Alabama District Court found that EPA's permit process for waste treatment and disposal under the Resource Conservation and Recovery Act (RCRA) should be considered the functional equivalent of NEPA. In *Alabamians For A Clean Environment* v. *EPA*,[35] four environmental groups had challenged the EPA's decision to grant a permit to an Alabama chemical waste treatment company attempting to secure a federal hazardous waste disposal permit from the EPA.

The plaintiffs successfully asserted that the district court had jurisdiction in the matter as they could not possibly exhaust their administrative remedies (within EPA) first, because the RCRA permit appeal process does not give an opportunity to address NEPA issues. They were not successful, however, in their substantive contention that when granting permits under RCRA, EPA must engage in the environmental review process mandated by NEPA for "*all* agencies of the Federal government."[36] The court, in rejecting that contention, pointed out that a long line of cases had recognized an exemption for the EPA where its adherence to the requirements of various organic statutes are the functional equivalent of NEPA.[37]

The court specifically held that the RCRA permitting process does give sufficient consideration for environmental matters and therefore is the functional equivalent of NEPA. Under RCRA, the court noted the numerous factors and standards pertaining to environmental protection which must be taken into account. These factors include: general waste and landfill standards, management of hazardous waste, chemical and physical analysis, and public comment and public hearing requirements.[38] The court, noting all of the above requirements stated, "In view of this pervasive system for taking environmental factors in account, it is evident that the RCRA process should be considered the "functional equivalent" of NEPA's EIS requirement."[39]

NEPA Litigation — 1988

United States Supreme Court

No National Environmental Policy Act cases were decided by the Supreme Court in 1988.

analyzed and their effectiveness explained when they have yet to be developed."[5] The court also noted the absence of a listing of techniques, such as the identification of "specific habitat development measures" and of the lack of analysis of the mitigation measures. The Court summed up its decision in *Marsh* by stating, "Without a complete mitigation plan, the decision-maker is unable to make an informed judgment as to the environmental impact of the project one of the main purposes of an environmental impact statement."[6]

On the issue of "worst case" analysis, both *Marsh* and *Methow Valley* held that such an analysis is necessary whenever an agency is unable to obtain information on which to base a reasoned decision or in the situation where the costs of obtaining the information are exorbitant. As these situations existed in both cases, the Court ruled that the EIS's of both the Corps of Engineers in *Marsh* and the Forest Service in *Methow Valley* were inadequate because neither agency had prepared the necessary worst case analysis. In coming to its decision, the Court had cited both *Save Our Ecosystems* v. *Clark*,[7] and CEQ's now rescinded "worst case" requirement at 40 C.F.R. 1502.22(b).[8] The Corps and the Forest Service had argued that §15022.22(b) is inapplicable due to its amendment by CEQ but the court rejected their contentions by citing *Clark* and by stating in a footnote that, "The worst case regulation is a codification of prior NEPA case law."[9] The two cases have been consolidated and accepted for *certiorari* by the U.S. Supreme Court.[10]

■ *Friends of the Earth v. Hintz*, 800 F.2d 822 (9th Cir. 1987).

A different aspect of mitigation was reviewed in *Friends of the Earth* v. *Hintz*.[11] Here, the Court considered the question of whether mitigation measures that are accomplished "off site" can be the basis for a Finding of No Significant Impact (FONSI) and the related decision not to draft an EIS. In *Hintz*, a logging company had applied to the Corps of Engineers for a 404 permit under the Clean Water Act[12] to fill a wetland that it was already utilizing. The timber company reported in their permit application that their log storage activities were water dependent and therefore site specific and proposed to mitigate the wetland loss by promising to purchase another site which could be converted to wetland.

Plaintiffs had contended that off-site mitigation measures which do not directly reduce impacts but only compensate elsewhere cannot justify a FONSI. The court disagreed, citing Corps regulations permitting off-site mitigation and CEQ regulations which define mitigation as including, "compensat[ion] for the impact by replacing or providing substitute resources or environment."[13] The court pointed out that where off-site mitigation is chosen, CEQ regulations do not specifically relieve an agency from preparing an EIS nor specifically require the preparation of an EIS. The court reasoned that since Corps regulations state that mitigation measures may be considered in determining if an EIS is necessary and that the Corps had specifically approved off-site mitigation then, "we see no reason why off-site mitigation cannot be considered in determining whether to prepare an EIS, just as on site mitigation."[14]

The plaintiffs also argued that the logging company's offer to purchase property for conversion to wetland could not be relied upon for a FONSI, as the offer was not part of the original proposal nor was it imposed by statute or regulation as stated by Question 40 of CEQ's document "40 Questions".[15] The Court however rejected this argument by stating that the courts have held that CEQ's 40 Questions Document "is not a regulation, but merely an informal statement and is not controlling authority."[16]

■ *Maryland Conservation Council Inc.* v. *Gilchrist*, 808 F.2d 1039 (4th Cir. 1987). *Taxpayers Watchdog* v. *Stanley, Inc.*, 819 F.2d 294 (C.A. D.C. 1987).

Two different approaches were taken in two 1987 appellate court decisions concerning the issue of segmentation. In *Maryland Conservation Council Inc.* v. *Gilchrist*,[17] Montgomery County officials had authorized the construction of portions of a highway designed to pass through Seneca Creek State Park. Approval to use the park for the highway had not been granted by the Department of the Interior at the time of the commencement of construction by the County and the plaintiffs contended that the County had violated NEPA by authorizing construction of segments of the highway before the requisite federal agencies reviewed the project plans. The two segments of the highway under construction by Montgomery County were to have been connected by the park portion.

The court agreed with the plaintiff, stating that, "Because it is inevitable that the construction of the highway will involve a major federal action, it follows that compliance with NEPA is required before any portion of the road is built."[18] Quoting CEQ regulation 1506.1(a)(2) the court in *Gilchrist* hinged the decision on whether "the program in fact violates NEPA and its regulations by limiting 'the choice of reasonable alternatives' available to federal decision-makers."[19] Pointing out that if investments in the highway route were made before the government official had considered the environmental report on the project, the judge wrote that the options open to the decision maker would diminish and at some point his consideration of the action would become a mere formality.[20] The court rejected the County's allegations that portions of the highway were not subject to federal approval by saying, "Non-federal actors may not be permitted to evade NEPA by completing a project without an EIS and then presenting the responsible federal agency with a *fait accompli*."[21]

A different approach was taken in *Taxpayers Watchdog* v. *Stanley, Inc.*,[22] in which the court concentrated on the question of whether the segmented part of a project was independently viable. In *Taxpayers*, the Urban Mass Transportation Administration (UMTA) had drafted an EIS for a proposed 4 mile section of a metro rail system in Los Angeles (titled MOS-1) without

United States Courts Of Appeals: Selected Decisions

■ *Connor* v. *Burford*, 836 F.2d 1521 (9th Cir. 1988). *Bob Marshall Alliance* v. *Hodel*, 852 F.2d 1223 (9th Cir. 1988).

The question of when an agency must prepare an EIS for oil and gas drilling in national forests has produced conflicting interpretations of requirements under the National Environmental Policy Act in the Ninth and Tenth Circuit Courts of Appeals. In a 1987 case, *Park County Resource Council, Inc.* v. *Department of Agriculture*,[40] the Court of Appeals for the Tenth Circuit held that the full development of lease areas cannot be predicted prior to oil exploration phase and that an EIS only need be prepared when site specific plans have been determined. The Court of Appeals for the Ninth Circuit, in two 1988 cases, has taken a different view. In *Connor* v. *Burford*[41] and *Bob Marshall Alliance* v. *Hodel*,[42] the Forest Service reviewed certain national forests to determine to what uses the forests would be classified. The Forest Service prepared environmental assessments (EAs) and recommended that large sections of these forest lands be leased for oil and gas development. Findings of No Significant Impact (FONSI) were issued based upon the assessment that the sale of the leases would have no significant effect on the environment. The Bureau of Land Management (BLM) then sold leases for oil and gas exploration and development. Some of the leases contained "no surface occupancy" (NSO) stipulations, which prohibit the lessee from engaging in any surface disturbing activity.

Plaintiffs (several environmental groups and landowners) contended that the sale of the leases without the preparation of EISs violated NEPA as the lease sales constituted an irretrievable commitment of resources. The Forest Service claimed that the decision to file a FONSI was correct because the environmental impacts could not be assessed at the time of the sale of the leases because no plans for specific exploration or mineral development activities had yet been proposed.[43] In addressing the issue of NSO leases the *Connor* court found that since these leases prohibited surface activity, any changes or modifications in the leases would trigger the requirement for the preparation of an EIS in later stages of development and therefore held that no EIS was required at the lease sale stage.[44]

However, both the *Connor* and *Bob Marshall* decisions distinguished NSO leases from non-NSO leases, following the holdings of the District of Columbia Circuit in *Sierra Club* v. *Peterson*.[45] The court rejected the contention of the Forest Service that NEPA is satisfied by a process of "staged consultation" under which the effects of surface disturbing activity are analyzed as specific activities are proposed[46] and that the activities of the applicants can be regulated at those stages.[47] The *Connor* court noted that the agency does not have the power to prohibit the lease holder from acting, eliminating the possibility of selecting the "no action" alternative as required by the Council on Environmental Quality regulations.[48] The court also rejected the government's contention that the activities of the applicants could be adequately regulated after the leases were issued. The court questioned "[w]hether the ability to subject such highly intrusive activities to reasonable regulation can reduce their effects to insignificance."[49]

Both decisions relied on NEPA's mandate that an EIS must be prepared before there is an irretrievable commitment of resources, and attempted to identify that commitment/no commitment stage by establishing the point at which the government loses its ability to prevent environmental degradation. The applicant in *Bob Marshall*, noting the apparent split between the Ninth and Tenth Circuits on the issue of when the EIS must be prepared, has filed petition for certiorari to the Supreme Court.[50]

■ *Natural Resources Defense Council* v. *Hodel*, ___ F.2d ___ (C.A. D.C. 1988).

The issue of the extent to which cumulative impacts must be examined arose in the context of Outer Continental Shelf (OCS) lease sales in *Natural Resources Defense Council* v. *Hodel*.[51] The plaintiffs challenged the adoption of a Department of Interior 5 year leasing program (from 1987 to 1992) asserting that the EIS did not adequately examine the cumulative impacts of simultaneous OCS mineral development in California and Alaska on migratory species such as whales and salmon. Plaintiffs, various environmental organizations and coastal states, contended that the cumulative impact of simultaneous development would be greater than the sum of development in each area because migratory species will have to pass through all of the areas.

The District of Columbia Court of Appeals agreed with the plaintiffs, citing *Kleppe* v. *Sierra Club*,[52] and CEQ regulations which "specifically provide that an EIS should consider together actions that 'are interdependent parts of a larger action and depend on the larger action for their justification.'"[53] The court quoted sections of the EIS under the subsection "cumulative impacts" and noted that only impacts *within* certain OCS areas or regions had been examined and not the impacts of simultaneous OCS development in different areas. Use of similar language in different sections of the FEIS regarding different regions or species was also rejected by the court which said, "When the FEIS does address inter-regional cumulative impacts, [illegible] simply repeats the same boilerplate for each area, varying the language only slightly in each instance."[54]

The court then set out the following factors to be used to guide agencies in determining what would satisfy the requirements in NEPA for the assessment of cumulative impacts: (1) impacts of simultaneous development should be examined in a "single, coherent section rather than fragmented analysis by area;" (2) references to "scientific studies and other materials that supported the agency's decision" should be presented; and (3) "the examination and comparison of alternatives to simultaneous development that would mitigate any synergistic impacts on species, such as staggering development" should also be included.[55]

■ *LaFlamme* v. *Federal Energy Regulatory Commission*, 842 F.2d 1063 (9th Cir. 1988).

The requirement to assess cumulative impacts was also examined in *LaFlamme* v. *Federal Energy Regulatory Commission*.[56] In *LaFlamme*, the Federal Energy Regulatory Commission (FERC) approved a permit for the construction of the Sayles Flat hydroelectric project on the American River in Northern California. FERC's FONSI was challenged by the plaintiffs who alleged that the EA did not adequately assess cumulative impacts of the water resources project. FERC in turn contended that their analysis of cumulative impacts was adequate because the EA for Sayles Flat had incorporated by reference a staff report on all American River hydroelectric projects.

The court, however, pointed out that the staff report section on cumulative impacts was based on an EIS previously prepared for a related American River hydroelectric project which was limited to the impacts of proposed facilities in that project's area. The court held that the previously prepared EIS, and therefore the staff report, did not provide the "necessary comprehensive cumulative impact of all projects in the area, especially the Sayles Flat Project." The court cited language from CEQ's cumulative impact regulation[57] and stated that "[s]uch a narrow analysis of one project's impact on this area cannot possibly provide the necessary broad consideration of all 'past, present and reasonably foreseeable future actions" required in the cumulative impact analysis.[58] The court, noting that the previous project EIS represented only the initial development of water resources projects on the American River, indicated that each project would have to be examined for its own particular impacts, including cumulative impacts.[59] By requiring that FERC examine each project and each impact individually as well as cumulatively, the court seemed to be rejecting the use of boilerplate language or analysis for separate parts of the EIS.

■ *Hudson River Sloop Clearwater Inc.* v. *Navy Department*, 836 F.2d 760 (2nd Cir. 1988).

The issue of segmentation was discussed in *Hudson River Sloop Clearwater Inc.* v. *Navy Department*,[60] in which plaintiffs asserted that the Navy improperly "segmented" their plans for housing for Navy personnel from the EIS for the nearby dredging and pier construction for the proposed Staten Island homeport. In its EIS for the Staten Island homeport, the Navy had examined the environmental impact of the housing needed for its married personnel. Subsequently the Navy was advised by the New York State Department of Environmental Conservation that much of the housing site was designated as wetlands subject to state regulation. The Navy then issued its Record of Decision in which much of the previously planned housing was reduced, delaying the planning of additional housing until later.[61]

The district court had enjoined construction of the homeport, agreeing with the plaintiffs contention that the construction of the port facilities and the eventual construction of housing were connected actions under CEQ regulation 40 C.F.R. 1508.25(a)(1) and that the impacts of both actions should have been discussed in a single EIS. The appellate court disagreed, overturning the injunction placed on the Navy's construction of the port facilities by the district court. The court of appeals cited 1508.25(a)(1)(ii) in its analysis, stating that actions are connected if they, "[c]annot or will not proceed unless other actions are taken previously or simultaneously."[62]

The question, according to the court of appeals, was, can "the operational aspects of the homeport proceed without the construction of family housing?"[63] Noting the district court's finding that military necessity required the Navy to proceed with the project even without providing housing, the court found that the operational aspects of the homeport could proceed without the housing and that therefore the two were not "connected" under subsection 1508.25(a)(1)(ii).

The court also briefly discussed whether the homeport and the facilities were connected under 1508.25(a)(1)(iii) which defines actions as connected if they "[a]re interdependent parts of a larger action and depend on the larger action for their justification."[64] The court cited *Taxpayers Watchdog, Inc.* v. *Stanley*,[65] for the "proper test for interdependence," which is whether the action being contested has an independent utility.[66] The court held that since the Navy was going to proceed with the port facilities with or without the housing, the port facilities had the requisite independent utility.[67]

The court however did not include a discussion of the Fourth Circuit's approach to segmentation cases as set out in *Maryland Conservation Council Inc.* v. *Gilchrist*.[68] In *Gilchrist*, the court determined that an EIS drafted to evaluate the impacts of a highway that crossed a county park must contain an analysis of the impacts caused by the section that would eventually pass through the park. *Gilchrist* held that the sections of the highway outside the park could not go forward because their approval would "limit the choices of alternatives that are available to federal officials."[69] The *Gilchrist* court reasoned that if investments in the highway route were made before the government official had considered an environmental analysis on the park section, the options open to the decision maker would diminish and at some point his consideration of the action would become a mere formality.[70] While the *Hudson Sloop* case may have been decided similarly if the court had utilized the *Gilchrist* test, the fact that the court did *not* use it indicates that there may be different approaches between the circuit courts on the analysis required in segmentation cases.

■ *Save the Yaak* v. *Block*, 840 F.2d 714 (9th Cir. 1988).

Both segmentation and cumulative impacts were discussed in the 9th Circuit decision, *Save the Yaak* v. *Block*.[71] The Yaak River Road in western Montana runs through extensive lodgepole pine stands that have been infested by the mountain pine beetle. The Forest Service planned to reconstruct the road in five separate sections to help accelerate harvest of these trees to salvage as many as possible. The Forest Service drafted five different EAs for each of the road sections.

Plaintiffs contended that the logging operations and the reconstruction of the road were "connected actions" under the CEQ regulations and therefore the Forest Service improperly segmented the logging operations by not assessing impacts of the logging operations in the EAs. The court agreed, finding "a clear nexus between the timber contracts and the improvement of the road."[72] The court noted that even though the Forest Service had not characterized the road as a logging road, the testimony established that the purpose of the road was to make the logging activity safer and more efficient and that there was no other reason to reconstruct the road. The court quoted *Thomas v. Peterson*,[73] for the applicable analysis that, "'[T]he road would not be [reconstructed] but for the contemplated timber sales.'"[74]

While the court did not expressly use the "independent utility" test (for determining segmentation) used in *Hudson Sloop*, a similar "but for" analysis was utilized. That is, in *Hudson Sloop*, the court held that the homeport had an independent utility, apart from the housing and that therefore construction of the homeport did not depend on the construction of the housing. In *Save the Yaak*, the court indicated that but for the timber operations there would have been no road reconstruction and that therefore the road had no independent utility.

In a separate section the *Save the Yaak* court addressed the closely related issue of whether cumulative impacts of the logging operations and the road construction "necessitates the preparation of an [EIS]." Noting the nexus established earlier in the decision, the court stated that "[t]he cumulative impact of these actions raises material issues of fact concerning the project's effect upon the human environment."[75] The court then reversed the district court's summary judgment for the Forest Service, holding that a FONSI could not be issued where the cumulative impacts of the road and the logging had not been examined together.

The court also addressed the issue of timing of the preparation of the environmental documents. The court stated that "timing is one of NEPA's central themes," and quoted 1502.5 which requires federal agencies to "integrate the NEPA process with other planning at the earliest possible time to insure that planning and decisions reflect environmental values . . . ."[76] The court determined that because the EA had been prepared *after* the Forest Service had awarded the reconstruction contract, then the EA was not drafted in a timely fashion, "thereby seriously impeding the degree to which their planning and decisions could reflect environmental values."[77]

■ *No GWEN Alliance of Lane County, Inc.* v. *Aldridge*, 855 F.2d 1380 (9th Cir. 1988).

Whether NEPA analysis is an appropriate context for discussing the impacts of nuclear war was addressed in *No GWEN Alliance of Lane County, Inc.* v. *Aldridge*.[78] GWEN (Ground Wave Emergency Network) is an Air Force system of 300 foot radio antennas that are designed to send war messages during and after a nuclear war. The Air Force issued a generic EA for the entire project and site specific EAs for each antenna tower, none of which included a discussion of the environmental impact of nuclear war. The plaintiffs contended that these documents should have considered the environmental impact of nuclear war and that these impacts should be discussed in the EAs because of the possibility that deployment of GWEN "could reasonably result in nuclear war."[79]

The Air Force's first response was to contend that *No GWEN's* suit to compel a discussion of the environmental impact of nuclear war raised only non-justiciable political questions. The court disagreed, noting that the plaintiffs were not seeking a review of the merits of the decision to deploy GWEN, but instead wanted to insure that the Air Force complied with NEPA by considering *all* environmental effects of constructing GWEN.[80]

Since the plaintiffs were not attacking the Air Force's decision on the merits but instead were attacking the inadequacies of the decision making process, the court held that "a lawsuit challenging development of a defense installation on the grounds that the responsible agency did not discuss environmental impacts causally related the installation raises justiciable questions.[81] The court, citing *Weinberger* v. *Catholic Action of Hawaii*[82] and *Concerned About Trident* v. *Rumsfeld*,[83] also pointed out that, "[t]here is no "national defense" exception to NEPA."[84]

The court also considered the substantive issue of whether NEPA requires a discussion of the impact of nuclear war that could result because of deployment of GWEN. Plaintiffs contended that their own speculation that GWEN would promote nuclear war should be discussed alongside the Air Force's contention that GWEN would deter it.

The court framed discussion of this issue as a question of whether there was a nexus between the installation of GWEN and the environmental impact of nuclear war. Citing *Warm Springs Dam Task Force* v. *Gribble*,[85] the court compared nuclear war to an earthquake and stated that since both experts and laymen agreed that the damage caused by such events was so catastrophic, detailing the results of such events serves no useful purpose.[86] The court then stated that, "Consequently, we hold that the nexus between construction of GWEN and nuclear war is too attenuated to require discussion of the environmental impacts of nuclear war in an environmental assessment or environmental impact statement."[87]

Table B-1. Cumulative NEPA litigation survey, 1970-1987[1].

YEAR	CASES FILED	INJUNCTIONS	MOST FREQUENT DEFENDANT	MOST FREQUENT PLAINTIFF	MOST COMMON COMPLAINT	SECOND COMMON COMPLAINT
1974	189		DOT; HUD			
1975	152					
1976	119		DOT; DOI; HUD	Citizen and Environmental Groups	No EIS	Inadequate EIS
1977	108		DOT;DOD;DOI	Cit. & Env. Gr.	No EIS	Inadequate EIS
1978	114		DOT; DOD; DOI; HUD; EPA	Cit. & Env. Gr. Individuals	No EIS	Inadequate EIS
1979	139	12	DOT; HUD; DOI; DOAg; DOD	Env. Gr.; Cit. Gr. & Ind.	No EIS	Inadequate EIS
1980	140	17	DOT; DOI; DOD; HUD; EPA	Ind. & Cit. Gr. Env. Gr.	No EIS	Inadequate EIS
1981	114	12	DOD; DOT; DOI; DOAg; HUD; NRC	Env. Gr.; Ind. & Cit. Gr.	No EIS	Inadequate EIS
1982	157	19	DOI; COE; DOT; DOAg; HUD; EPA	Ind. & Cit. Gr. Env. Gr.	Inadequate EIS	No EIS
1983	146	21	DOI; DOT; DOA; FERC; NRC	Ind. & Cit. Gr. Env. Gr.	No EIS	Inadequate EIS
1984	89	14	DOAg; DOI; DOT	Env. Gr.; Ind. & Cit. Gr.	Inadequate EIS	No EIS
1985	77	8	DOT; DOI; COE; FERC	Env. Gr.; Ind. & Cit. Gr.	No EIS	Inadequate EIS
1986	83	16	DOT; DOI; DOAg; COE	Ind. & Cit. Gr.; Env. Gr.	No EIS	Inadequate EA & EIS
1987	80	3	DOI; DOT; DOAg; COE	Env. Gr.; Ind. & Cit. Gr.	No EIS	Inadequate EA

[1] 1970-1975: A cumulative survey on these years was published in the 1976 Annual Report. By June 30, 1975, 332 NEPA cases had been completed, resulting in 54 injunctions. 322 cases were still pending with 65 injunctions. The most frequent defendants were the Departments of Transportation and Housing and Urban Development.

Table B-2a. NEPA cases by agency, 1986.

AGENCIES	NUMBER OF CASES FILED	NUMBER OF 1986 CASES RESULTING IN INJUNCTIONS	NUMBER OF INJUNCTIONS IN 1986 FROM PRE-1986 CASES
Department of Agriculture	7	3	0
Department of the Air Force	4	0	0
Department of the Army	2	0	0
U.S. Army Corps of Engineers	8	0	1
Department of Housing & Urban Development	1	1	0
Department of the Interior	12	3	0
Department of Transportation	32	7	0
Environmental Protection Agency	5	0	0
Federal Communications Agency	1	0	0
Federal Energy Regulatory Commission	2	0	0
National Capital Planning Commission	1	0	0
National Oceanic and Atmospheric Administration	4	0	0
Nuclear Regulatory Commission	3	1	0
Postal Service	1	1	0
TOTAL	83	16	1

Table B-2b. NEPA cases, by agency, 1987.

AGENCIES	NUMBER OF CASES FILED	NUMBER OF 1987 CASES RESULTING IN INJUNCTIONS	NUMBER OF INJUNCTIONS IN IN 1987 FROM PRE-1987 CASES
Department of Agriculture	7	1	0
Department of the Air Force	5	0	0
Department of the Army	2	0	0
U.S. Army Corps of Engineers	11	0	0
Department of Commerce	4	2	1
Department of Defense	3	0	0
Department of Energy	3	0	0
Department of Health & Human Services	1	0	0
Department of Housing & Urban Development	5	0	0
Department of the Interior	10	0	2
Department of the Navy	5	0	0
Department of State	1	0	1
Department of Transportation	7	0	1
Department of Treasury	1	0	0
Environmental Protection Agency	5	0	0
Federal Energy Regulatory Commission	2	0	0
Interstate Commerce Commission	4	0	0
Nuclear Regulatory Commission	3	0	0
Tennessee Valley Authority	1	0	0
TOTAL	80	3	5

Table B-3a. Types of complaints filed under NEPA, 1986.

CAUSES OF ACTION	NUMBER FOR 1986 CASES	FOR PRE-1986 CASES RESULTING IN INJUNCTIONS IN 1986
Inadequate Environmental Impact Statement	18	0
No Environmental Impact Statement, when one should have been prepared	39	0
Inadequate Environmental Assessment	18	0
No Environmental Assessment, when one should have been prepared	8	0
No Supplemental Environmental Impact Statement, when one should have been prepared	3	1
Other	2	0
TOTAL	88	1

Table B-3b. Types of complaints filed under NEPA, 1987.

CASES OF ACTION	NUMBER FOR 1987 CASES	FOR PRE-1987 CAUSES RESULTING IN INJUNCTIONS IN 1987
Inadequate Environmental Impact Statement	15	2
No Environmental Impact Statement, when one should have been prepared	46	1
Inadequate Enviornmental Assessment	17	0
No Enviornmental Assessment, when one should have been prepared	7	1
No Supplemental Enviornmental Impact Statement, when one should have been prepared	5	1
Other	8	0
TOTAL	98	5

Table B-4a. Plaintiffs for NEPA lawsuits, 1986.

TYPES OF PLAINTIFFS	NUMBER FOR 1986 CASES	NUMBER FOR PRE-1986 CASES RESULTING IN INJUNCTIONS IN 1986
Environmental Groups	33	0
Individuals or Citizen Groups	31	1
State Governments	4	0
Local Governments	11	0
Business Groups	6	0
Property Owners or Residents	8	0
Indian Tribes	2	0
TOTAL	95	1

Table B-4b. Plaintiffs for NEPA lawsuits, 1987.

TYPES OF PLAINTIFFS	NUMBER FOR 1987 CASES	NUMBER FOR PRE-1987 CASES RESULTING IN INJUNCTIONS IN 1987
Environmental Groups	33	4
Individuals or Citizen Groups	31	2
State Governments	8	1
Local Governments	11	0
Business Groups	2	0
Property Owners or Residents	11	1
Indian Tribes	6	0
TOTAL	102	8

Table B-5a. Statistics on plaintiffs and issues for 1986 cases, by agency.

AGENCY	USDA	AIR FORCE	FCC	NCPC	NRC	POSTAL	DOT	ARMY	COE	EPA	FERC	DOI	NOAA	HUD
PLAINTIFF														
Environmental Groups	6			1	3	1	6	2	5	2		5	2	
Individual Citizen Groups		3	1	1			17		1	1	2	3	2	
State Governments							1		1			2		
Local Governments	1						8		1			1		
Businesses							4		1			1		
Property Owners or Residents	1	1		1			2		1	2				1
Indian Tribes									1			2		
TOTALS	8	4	1	3	3	1	38	2	9	5	2	14	4	1
ISSUE														
Inadequate EIS	1				2		11		1	1		2		
No EIS	3	3			1	1	13	2	3	3	1	6		1
Inadequate EA	1	1		1			4	1	5			3		
No EA	2		1				3				1			
No Supplemental EIS							3							
Other											2			
TOTALS	7	4	1	1	3	1	34	3	9	4	1	14		1

Table B-5b. Statistics on plaintiffs and issues for 1987 cases, by agency.

AGENCY	FERC	NRC	TVA	EPA	ICC	USDA	USAF	ARMY	COE	DOC	DOD	DOE	HHS	HUD	DOI	STATE	DOT	TREAS	NAVY
PLAINTIFF																			
Environmental Groups	1	2		1	3	5	1		4	3	1	3			8			1	
Individual Citizen Groups		1		1	1	1	4	3	5	2	1	2	1	2	1		3		3
State Governments		1			1						1				2	1	1		1
Local Governments				2	2				3					1	2				1
Businesses						1											1		
Property Owners or Residents			1	1		2			1					2	1		2	1	
Indian Tribes	2					1			1						1		1		
TOTAL	3	4	1	5	7	10	5	3	14	5	3	5	1	5	15	1	8	2	5
ISSUE																			
Inadequate EIS	1					2	1	1	1	1				2	3		1		2
No EIS		2	1	3	1	4	4	1	8	1	3	2	1	3	1	1	6	1	3
Inadequate EA	1	1				3	1	1	3		1	1			3		1		1
No EA							1	1		1			1				1	1	1
No Supplemental EIS									1	2			1		1				
Other				2	3					1					2				
TOTAL	2	3	1	5	4	9	7	4	13	6	4	3	3	5	10	1	9	2	7

■ *Natural Resources Defense Council* v. *U.S. Environmental Protection Agency*, 859 F.2d 156 (D.C. Cir. 1988).

The authority of an agency to impose conditions pursuant to NEPA was addressed in *Natural Resources Defense Council* v. *U.S. Environmental Protection Agency*.[88] Several industry and environmental groups sought judicial review of regulations of the Environmental Protection Agency (EPA) dealing with conditions placed on permits granted under the National Pollution Discharge Elimination System permits under the Clean Water Act.[89] Section 1371(c) of the Clean Water Act provides that the provision of federal financial assistance for the construction of publicly owned treatment works and the issuance of discharge permits to new sources are federal actions that require EPA to carry out the requirements of NEPA.[90] Utilizing this provision, EPA outlined a system whereby it could subject NPDES permits to conditions not related to water quality.[91]

Industry groups challenged the validity of this system, including 40 C.F.R. §122.44(d)(9) which states that the Administrator of the EPA shall issue or condition NPDES permits, providing that new source NPDES permits shall "incorporate . . . appropriate requirements, conditions, or limitations . . . *to the extent allowed by [NEPA] and section 511 of the CWA*."[92] EPA contended that NEPA authorizes the agency to make decisions based on environmental factors not expressly identified in the agency's underlying statute. The court agreed with this general proposition. EPA also argued that NEPA permits the agency not only to consider environmental factors, but also to act on these factors by imposing any condition necessary related to the environmental effects of the entire new facility. The court disagreed and held specifically that, "neither the Clean Water Act nor NEPA authorizes EPA's imposition of nonwater quality permit conditions for NPDES permits."[93] The court explained its holding by stating that "[a]ny action taken by a federal agency must fall within the agency's appropriate province under its organic statute(s)."[94]

The court emphasized that NEPA *does* instruct agencies to incorporate information concerning environmental impacts into its decisions. Thus, where the agency holds the authority to deny a source permit or impose certain types of conditions, that agency can take action "in the wake of its NEPA-mandated review" by basing its actions on information or analysis set out in the NEPA documents.[95] The court, therefore, did not limit an agency's authority to consider environmental impacts in its decisions but held only that NEPA does not expand the authority of an agency to make certain kinds of decisions or orders.

Trends in NEPA Litigation

CEQ's survey of NEPA litigation filed against federal agencies during 1986 and 1987 showed a continuation of the trend towards significantly lower numbers of cases than were filed during the first decade of NEPA implementation. Similarly, the number of injunctions issued against the government remained low, with only three injunctions issued based on cases filed during 1987. Table B-1 displays cumulative NEPA litigation information for the years 1974-1987.

Individual and citizen groups and environmental groups were the most frequent plaintiffs during both 1986 and 1987. The Department of Transportation, Department of Interior, Department of Agriculture and the Corps of Engineers were the agencies most frequently sued as defendants. As is typical, the most common cause of action was the allegation that no EIS had been prepared for a proposed action which required an EIS; the second most common complaint for 1986 was that an EIS or an environmental assessment (EA) was inadequate. In 1987, the second most common complaint concerned the alleged inadequacy of an EA, pointing to the increased use by agencies of EAs and the concomitant increase in scrutiny which these EAs and Findings of No Significant Impact are receiving. See Table B-2a for NEPA Cases by Agency: 1986; Table B-2b for NEPA Cases by Agency: 1987; Table B-3a for Types of Complaints Filed under NEPA: 1986; Table B-3b for Types of Complaints filed under NEPA: 1987; Table B-4a for Plaintiffs for NEPA Lawsuits: 1986; Table B-4b for Plaintiffs for NEPA Lawsuits: 1987; Table B-5a for Statistics on Plaintiffs and Issues for 1986 cases within each department and agency; and Table B-5b for the same information for 1987 cases. Table B-6 provides information on the number of EISs filed by each federal agency during 1987. A total of 455 draft, final and supplemental EISs were filed in 1987. Information on the number of EISs filed by each federal agency during 1988 is not yet available.

Table B-6. Environmental impact statements filed by federal agencies, 1987.

AGENCY	TOTALS BY SUBJECT MATTER	TOTALS
U.S. Department of Agriculture		75
Sewage Treatment and Sewage Facility	1	
Watershed Protection and Floodplain Control	11	
Parks, Recreation Areas, Wilderness Areas, National Seashores	6	
Forestry and Range Management	34	
Pesticides, Herbicides Use	11	
Natural Gas and Oil: Transportation, Pipeline, Storage	2	
Irrigation, Desalination of Return Flows, Agriculture Water Supply	2	
Multi-purpose Impoundment	1	
Mining (Non-energy)	2	
Comprehensive Resource Management	1	
Navigation	1	
Natural Gas and Oil: Drilling and Exploration	2	
Municipal and Industrial Water Supply Systems (except multi-purpose impoundments)	1	
U.S. Department of Commerce		9
Wilderness Refuges, Fish Hatcheries	3	
Wetlands, Estuary and Ocean Use (Sanctuary, Disposal, etc.)	4	
Fisheries	2	
U.S. Department of Defense		2
Military Installations (Conventional, Chemical, Nuclear, etc.)	2	
U.S. Department of the Air Force		9
Defense Systems	5	
Natural Gas and Oil: Drilling and Exploration	2	
Munition Disposal	1	
Aircraft, Ships and Vehicles	1	
U.S. Department of the Army		10
Defense Systems	1	
Munitions Facilities	1	
Military Installations (Conventional, Chemical, Nuclear, etc.)	6	
Munitions Disposal	2	
U.S. Army Corps of Engineers		76
Mining	1	
Natural Gas and Oil: Transportation, Pipeline, Storage	1	
Power Facilities: Fossil	1	
Munition Disposal	1	
Municipal and Industrial Water Supply Systems (except multi-purpose impoundments)	5	
Beach Erosion, Hurricane Protection, River/Lake Bank Stabilization	5	
Navigation	16	
Multi-purpose Impoundments	6	
Watershed Protection and Flood Control	22	
Dredge and Fill	12	
Other Water Projects	4	
Road Construction	1	
Parks, Recreation Areas, Wilderness Areas, National Seashores	1	

Table B-6. (cont.) Environmental impact statements filed by federal agencies, 1987.

AGENCY	TOTALS BY SUBJECT MATTER	TOTALS
U.S. Department of the Navy		9
Military Installations (Conventional, Chemical, Nuclear, etc.)	4	
Power Facilities: Conservation	1	
Land Acquisition or Disposal	1	
Buildings, Federally Licensed or Assisted (including production facilities)	2	
Housing Subdivisions and New Communities	1	
U.S. Department of Energy		11
Radio Active Waste Disposal	4	
Power Facilities:		
Transmission	3	
Conservation	1	
Nuclear Development (e.g., Fuel, Reactors)	1	
Industrial Wastewater Facilities: Mine Pollution Control	2	
U.S. Environmental Protection Agency		19
Ocean Dredged Material Disposal Sites	10	
Emission Regulations	3	
River Cleanup	1	
Wastewater Treatment	3	
Containment Facilities Construction	2	
General Services Administration		1
Federal Building Construction	1	
U.S. Department of Housing and Urban Development		6
Flood Control	1	
Housing Subdivisions and New Communities	3	
Urban Programs	2	
U.S. Department of the Interior		110
Mining	3	
Natural Gas and Oil: Drilling and Exploration	11	
Transportation, Pipeline, Storage	4	
Power Facilities: Transmission	4	
Municipal and Industrial Water Supply	2	
Irrigation, Desalination of Return Flows, Agricultural Water Supply	1	
Multi-purpose Impoundments	1	
Dredge and Fill	1	
Other Water Projects	1	
Road Construction	1	
Land Acquisition or Disposal	1	
Parks, Recreation Areas, Wilderness Areas, National Seashores	25	
Wildlife Refuges, Fish Hatcheries	13	
Forestry and Range Management	14	
Mining (non-energy)	2	
Comprehensive Resources Management	22	
Pesticides, Herbicides Use	2	
Hunting Regulation	1	
Miscellaneous	1	

Table B-6. (cont.) Environmental impact statements filed by federal agencies, 1987.

AGENCY	TOTALS BY SUBJECT MATTER	TOTALS
Interstate Commerce Commission		2
Railroad Abandonment	2	
Nuclear Regulatory Commission		3
Power Facility Nuclear	1	
Radioactive Waste Disposal	2	
Tennessee Valley Authority		0
U.S. Department of Transportation		101
Road Construction	89	
Bridge Permits	4	
Airport Improvements	4	
Mass Transportation	4	
Federal Energy Regulatory Commission		8
Natural Gas and Oil: Transportation, Pipeline, Storage	2	
Power Facilities: Hydroelectric	6	
U.S. Department of Justice		3
Prison Construction	3	
National Aeronautics and Space Administration		1
Space Program	1	
Total EIS's		455

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Special Report

State Environmental Impact Assessment Laws:

Legal authorities, significant cases, and state contacts

I. Arkansas

Permits Branch, Arkansas Department of Pollution Control and Ecology

Ark. Stat. Ann. §8-1-101 (1987).

The EIR process in Arkansas is coordinated through a clearinghouse, the Office of Intergovernmental Operations. EIRs covering matters requiring state permits or state funding are distributed for review to a consortium of fourteen state agencies, including the Department of Pollution Control and Energy.

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II. California

Cal. Pub. Res. Code §21000 *et seq*. (West 1982).

The Environmental Impact Report (EIR) process is described in the California Environmental Quality Act (CEQA). The Office of Planning and Research is responsible for the dissemination of EIR review to the appropriate permitting state agency.

California state CEQA Guidelines: Cal. Admin. Code, tit. 14, §15000 *et seq*.

A. Threshold Decision: Preparation of an EIR

Burger v. *County of Mendacinoy 45 Cal. App. 3d 322, 119 Cal. Rptr. 568 (1975)*
Court of Appeal found building permit was not exempt from CEQA.

Twain Herte Homeowners Ass'n.y Inc. v. *Tuolumne County*, 138 Cal. App. 3rd 664, 188 Cal. Rptr. 233 (1982).
The EIR should provide the public as well as public agencies with information about the effect which a proposed project will have on the environmenty *alternatives to the project and ways in which significant effects can be minimized.*

Christward Ministry v. *Superior Court*, 184 Cal. App. 3d 180, 228 Cal. Rptr. 868 (1986).
A city which intend to create a solid waste management facility and apply it to a nearby landfill, which is close to a religious retreat area, must prepare an EIR before development.

Inyo County v. *City of Los Angeles*, 71 Cal. App. 3d 185, 139 Cal. Rptr. 396 (1977).
The EIR is the heart of the environmental control process.

Pacific Water Conditioning Ass'n., Inc. v. *City of Riverside*, 73 Cal. App. 3d 546, 140 Cal. Rptr. 812 (1977)
If a public agency determines that a proposed project will not have a significant effect on the environment, it may declare in a negative declaration that no EIR is required.

No Oil, Inc. v. *City of Los Angeles*, 13 Cal. 3d 68, 529 P.2d 66, 118 Cal. Rptr. 34 (1974)
Under CEQA, an EIR is required before an agency approves a project.

City of Carmel-by-the-sea v. *Monterey County Bd. of Supervisors*, 71 Cal. App. 3d 84, 139 Cal. Rptr. 214 (1977).
A county zoning administrator must give consideration to an EIR before deciding to issue a use permit for a proposed motel development under CEQA.

City of Antioch v. *City Council of City of Pittsburgh*, 187 Cal. App. 3d 1325, 232 Cal. Rptr. 507 (1986).
A city must prepare an EIR for a proposed road and sewer construction project even though there existed uncertainty as to the precise plans and form of the construction.

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Citizens for Non-Toxic Pest Control v. *California Dep't of Food and Agriculture*, 187 Cal. App. 3d 1575, 232 Cal. Rptr. 729 (1986)
The Department of Food and Agriculture is required to prepare an EIR before it may implement a fruit fly eradication project.

City of Ukiah v. *Mendocino County*, 192 Cal. App. 3d 1324, 238 Cal. Rptr. 139 (1987).
The determination which must be made in deciding whether to require an EIR is whether the "project" being approved may have a significant effect on the environment. A "project" is defined to mean private activities "involving the issuances to a person of a lease, permit, license, certificate, or other entitlement for use by one or more public agencies".

Friends of Westwood, Inc. v. *City of Los Angeles*, 191 Cal. App. 3d 259, 235 Cal. Rptr. 788 (1987).
The court held, in essence, that the City's building permit for large buildings was so complicated that it must be considered discretionary and, therefore, subject to CEQA.

Dehne v. *Santa Clara County*, 115 Cal. App. 3d 827, 171 Cal. Rptr. 753 (1981).
Preservation of a landmark is akin to a mere replacement of an existing facility, which California exempts.

B. Scoping

Citizens to Preserve the Ojai v. *Ventura County*, 176 Cal. App. 3d 421, 222 Cal. Rptr. 247 (1985)
EIR on the proposed expansion of an oil refinery was required to explain the cumulative impact of offshore emissions and their feasibility.

Mira Monte Homeowners Ass'n v. *San Buenaventura County*, 165 Cal. App. 3d 357, 212 Cal. Rptr. 127 (1985).
The EIR must identify significant environmental effects of a proposed project, feasible mitigation measures, alternatives and significant environmental changes which will take place.

City of Del Mar v. *City of San Diego*, 133 Cal. App. 3d 401, 183 Cal. Rptr. 898 (1982).
A City has fulfilled its requirement under CEQA if it has properly analyzed all feasible alternatives to a project and determines to reject all those which, in their view, are not feasible.

Stevens v. *City of Glendale*, 125 Cal. App. 3d 986, 178 Cal. Rptr. 367 (1981).
The EQCA requires agencies to outline specific physical, social and economic reasons for rejecting particular alternatives to a project.

C. Draft Environmental Impact Report (DEIR)

City of Poway v. *City of San Diego*, 155 Cal. App. 3d 1037, 202 Cal. Rptr. 366 (1984).
A DEIR which identified local traffic circulation as "having a significant environmental effect and points out the need for specific mitigation measures" is sufficient as an informative document.

Foundation for San Francisco's Architectural Heritage v. *City and County of San Francisco*, 106 Cal. App. 3d 893, 165 Cal. Rptr. 401 (1980).
The Court upheld the right of the applicant to prepare the EIR.

D. Comment and Hearing and Final EIR

The Orinda Ass'n v. *Board of Supervisors of Contra Costa County*, 182 Cal. App. 3d 1145, 227 Cal. Rptr. 688 (1986).
The Building Inspection Department may not issue a permit for the demolition of historic buildings before the environmental process is completed and the entire project is lawfully approved.

Long Beach Sav. *& Loan Ass'n v. Long Beach Redev. Agency*, 188 Cal. App. 3d 249, 232 Cal. Rptr. 772 (1986).
A negative declaration or a decision not to prepare an EIR is an informative document which can be reviewed by interested parties or by court.

Laural Heights Improvement Ass'n of San Francisco v. *Regents of Univ. of California*, 193 Cal. App. 3d 1561, 193 Cal. App. 3d 467, 238 Cal. Rptr. 451 (1987).
CEQA requires "an interactive process of assessment of environmental impacts, which must be genuine and open to the public, premised on a full and meaningful disclosure of the scope, purposes, and effect of a project".

Citizens for Quality Growth v. *City of Mount Shasta*, 243 Cal. Rptr. 727 (1988).
The City Council of Mount Shasta, which reclassified a 35-acre parcel of land in the city, was forced to set aside its actions because of a failure to consider potential physical effects of the rezoning, and where no mitigating measures to prevent loss of wetlands were advanced.

E. California Law Review Articles

Application of Environmental Impact Report Requirement of the California Environmental Quality Act of 1970 to Rate Hearings of Electric Utilities, 8 U.S.F.L. Rev. 752 (1974).

California Environmental Quality Act Significant Effect or Paper Pollution?, 5 pac. L.J. 26 (1974).

Cautions Updating of the Envionmental Impact Statement Process, 11 Cal. W.L. Rev. 297 (1975).

Comments on California Rule-Making Process and Effects Thereon of California Environmental Quality Act, 5 U.C.D.L. Rev. 309 (1972).

Duty of Private Parties to File Environmental Statement, 61 Calif. L. Rev. 559 (1973).

Effectiveness of Environmental Impact Reports as an Implementation of the California Environmental Quality Act, 6 San Fern. V.L. Rev. 127 (1978).

Environmental Decision Making Under CEQA, 24 UCLA L. Rev. 838 (1977).

Is the State Environmental Act an Endangered Species?, 4 Cal. Lawyer No. 4, at 45 (1984).

Selmi, *Judicial Development of the California Environmental Quality Act*, 18 U.C.D. L. Rev. 197 (1984).

Possible Future Projects: Their Role in Environmental Assessments Under the California Environmental Quality Act, 21 Santa Clara L. Rev. 727 (1981).

Longtin, California Land Use Regulation (2d ed. 1987) (overview of CEQA's requirements).

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III. Connecticut: Environmental Protection Act of 1970

Conn. Gen. Stat. Ann. §§22a-14-to 22a-20 (West Supp. 1974-1975)
Connecticut's centralized environmental review process, "CEPA", applies only to projects which see State funding. Generally, regulatory decisions of State agencies do not require CEPA review; however, if the project is likely to have an environmental impact, an Environmental Impact Evaluation (EIE) is prepared. If the project will not have a significant impact upon the environment, a Finding of No Significant Impact (FONSI) is prepared. The process is reviewed and ultimately a final determination is made by the State Office of Policy Management (OPM).

A. Cases

Town of Westport v. *State*, 204 Conn. 212, 527 A.2d 1177 (1987).
The State's failure to prepare an EIE was excused because of a statutory exemption for "emergency measures" undertaken in response to an immediate threat to public health or safety. Here, a temporary truck weighing inspection station was constructed in response to a perceived crisis of a rise in accident rate caused by an increase in traffic after the removal of toll barriers on the highway.

Manchester Envtl. Coalition v. *Stockton*, 184 Conn. 51, 441 A.2d 68 (1981).
An EIE is required whenever the project will "arguably damage" the environment. Where the approval of the development of an industrial park preceded the submittal or

preparation of an EIE, it must be shown that consideration of environmental factors and research of alternatives has been made.

B. Law Review Article

CEPA Update 14 Conn. L. Rev. 695 (1982).

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IV. Florida

Fla. Stat. §§380.92 *et seq.*
Florida's "little NEPA", the Florida Environmental Land and Management Act of 1972, provides for a regional impact statement for certain designated development projects. Also, an environmental review process is associated with state permitting activities, such as projects under the Florida Power Plan Siting Act.

Law Review Commentaries
Kavanaugh, Florida Land and Water Management Act: Local Decision making and the DRI Process, 55 Fla. Bar J. 459 (1981).
Florida's DRI Statute: Alternatives to the Standard DRI Review, 13 Stetson L. Rev. 619 (1984)
Judicial Interpretation of Florida's Development of Regional Impact, 53 Fla. Bar J. 633 (1974).

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V. Hawaii

Hawaii Rev. State. §343-1 to 343-8 (1985).
The environmental review process under Hawaii's "NEPA" law applies to all projects seeking to utilize state or county funds which may have a significant effect upon the environment. The Department of Land and Natural Resources acts as the reviewing agency.

Pearl Ridge Estates Community Ass'n v. *Lear Siegler*, Inc., 65 Hawaii 133, 648 P.2d 702 (1982).
When an "application is made for the reclassification of conservation lands to other uses, an environmental assessment is necessary before the Land Use Commission can reclassify the lands".

McGlone v. *Uoshimitsu*, 64 Haw. 27, 636 P.2d 158, 12 E.L.R. 20338 (1981).
Where the Board of Land and Natural Resources approved the construction of underground utilities on a conservation land, the Supreme Court of Hawaii held that there would be no significant impact on the area, and no EIS was required.

Molokai Homesteaders Coop. Ass'n v. *Cobb*, 63 haw. 453, 629 P.2d 1134 (1981).
The prescribed role of the EIS in the State environmental process is largely informational. The Hawaii law, "by particularizing the subjects of inquiry, calls for a broader range of information than NEPA".

Life of the Land v. *Ariyoshi*, 59 haw. 156, 577 P.2d. 1116, 8 E.L.R. 20585 (1978).
The Environmental Quality Commission's regulations recognize that inclusion in an EIS of a cost-benefit analysis is discretionary. The determination to prepare an EIS includes the consideration of Environmental, economic and social effects on the community.

Hewitt v. *Waikiki Shopping Plaza*, 722 P.2d 1055 (1986).
The shopping plaza did not have to file an EIS because its application was pending approval on the effective date of the new EIS regulations.

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VI. Indiana

Ind. Code Ann. §§13-1-10-1 to 13-1-10-8 (West 1987).
Indiana's Environmental Policy Act in part parallels 42 U.S.C. 4332 (c)(1); thus, the state Court of Appeals found Indiana's act subject to the same interpretation in the Ziliak case, below.

Indiana State Highway Comm'n v. *Ziliak*, 431 N.E.2d 842 (1982).
A highway project which requires the utilization of federal funds requires compliance with NEPA and thus requires the preparation of an EIS before the decision to commit federal funds is made. AN EIS should be filed early in the planning states and prior to the initiation of condemnation proceedings.

Indiana Environmental Management Bd. v. *Indiana-Kentucky Elec. Corp.*, 181 Ind. App. 570, 393 N.E.2d 213 (1979).
Pursuant to the Indiana code, all major state actions significantly affecting the quality of the human environment, and including recommendations for legislation, must prepare an EIS.

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VII. Maryland

Md. Nat. Res. Code Ann. §§1-301 to 1-305 (1983 an Supp. 1987).
The environmental review process is associated with Maryland's permitting activities. All permit applicants must fill out an environmental assessment form at the time of application. The Department of Natural Resources (DNR) and the Department of Health and Mental Hygiene are the reviewing agencies.

Baylin v. *State Roads Comm'n*, 300 Md. 1, 475 A.2d 1155 (1984).
The environmental review process was undertaken in a condemnation proceeding which involved the contemplation of construction of a highway and mass transit facility.

Boswell v. *Prince George's County*, 273 Md. 522, 330 A.2d 663 (1975).
An EIS was not required where revenue sharing bonds were used for a "small road project".

A.H. Smith Sand & Gravel v. *Department of Natural Resources*, 270 Md. 652, 313 A.2d 820 (1974).
The Department of Water Resources has power with regard to flood plain control and could require that no filling operations could take place within a 50-year flood plain boundary without obtaining a permit from the Department.

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X. Minnesota

Minn. Stat. Ann. §116D.01 to 07 (West 1977 and Supp. 1981).
The Minnesota "little NEPA" law requires the preparation of an Environmental Assessment Worksheet (EAW) to determine whether a formal EIS must be prepared. EISs are generally prepared on a project by project basis and reviewed by the agency which has jurisdiction over that particular type of project.
Administrative Rules: Minn. Code Agency part 4110. 4400.

A. Minnesota Cases

Coon Creek Watershed Dist. v. *Minnesota Envtl Quality Bd.*, 315 N.W.2d 604 (1982).
An EIS can be required for a statutorily mandated repair of a county ditch.

Urban Council on Mobility v. *Minnesota Dep't of Natural Resources*, 289 N.W.2d 729 (1980).
Substantial evidence supported the determination that the highway route selected was superior to routing the highway

across a lake because the selected route would have less of an impact on water quality, wildlife habitat, aesthetics and area quietude.

People for Envtl. Enlightment & Responsibility v. *Minnesota Envtl. Quality Council*, 266 N.W.2d 858 (1978).
In order to satisfy the requirements of MEPA, an EIS must be prepared and be available for guidance of the agency prior to the selection of a specific route or approval of a project.

No Power Line v. *Minnesota*, 262 N.W.2d 312 (1977).
The Environmental Quality Council has jurisdiction over routing of high-voltage lines. While it would have been preferable to have required an EIS at the corridor selection stage of the proceedings, the commission's failure to do so did not constitute reversible error.

Minnesota Public Interest Research Group v. *White Bear Rod & Gun Club*, 257 N.W.2d 762 (1977).
Evidence established a prima facie case that operation of the gun club would materially affect the surrounding environment. The city had no authority to issue a permit which allows pollution, impairment or destruction of the environment.

Minnesota v. *City of Breezy Point*, 394 N.W.2d 592 (1986).
The court used the EIS, which described the entire campsite development project, to interpret disputed contractual provisions.

Rolander v. *Meeker County*, 392 N.W.2d 675 (1986).
Permits for a mining waste disposal site shall not be issued if there is a substantial likelihood that the project will adversely affect the environment.

B. Minnesota Law Review Articles

Animal Feedlot Regulations in Minnesota, 7 Wm. Mitchell L. Rev. 399 (1981).

Environmental Policy Act In re City of White Bear Lake, 4 Wm.Mitchell L. Rev. 238 (1978).

Environmental Rights in Theory and Practice, 62 Minn. L. Rev. *163 (1976).*

Environmental Statutes and Rules Affecting Development Projects in Minnesota, 44 Hennepin Law. 10 (July-Aug. 1976).

Land Use and Police Power, 42 Hennepin Law. 12 (Jan.-Feb. 1974).

Power Line Routing, 63 Minn. L. Rev. 707 (1979).

Preserving Minnesota Wetlands, 6 Wm. Mitchell L. Rev. 137 (1981).

State Intervention in Local Land Use Regulation, 63 Minn. L. Rev. 1259 (1979).

Zoning: Minnesota Supreme Court 1971-1972, 57 Minn. L. Rev. 940 (1973).

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XI. Montana

Mont. Code Ann. §§75-1-101 to 75-1-105; 75-1-201 (1981).
Montana's Environmental Policy Act (MEPA) requires the preparation of an EIS for any major State action significantly affecting the environment. The permit applicant must prepare a Preliminary Environmental Review (PER) statement prior to submitting a DEIS or FEIS. The Department of Natural Resources and the Department of State Lands are responsible for review.

A. Cases

State ex rel. Montana Wilderness Ass'n v. *Board of Natural Resources and Conservation*, 200 Mont. 11, 648 P.2d 734, 13 E.L.R. 20530 (1982).
AN EIS substantially complies with the mandates of MEPA when "environmental disclosure is sufficiently detailed to aid in the substantive decision whether to proceed with the project". Where a power company files an application to construct and operate a high-voltage electrical transmission line, it is not necessary that every possible alternative be considered in the EIS.

Guthrie v. *Department of Health & Envtl. Sciences*, 172 Mont. 142, 561 P.2d 913 (1977).
Where an injunction was sought to halt subdividers from physically altering their land and where it is found that their

actions would significantly affect the environment, venue is proper in the county in which the project is taking place.

Montana Wilderness Ass'n v. *Board of Health & Envtl. Sciences*, 171 Mont. 477, 559 P.2d 1157, 7 E.L.R. 20170 (1976).
MEPA does not extend the Department of Health and Environmental Sciences control over subdivisions "beyond matters of water supply, sewage and solid waste disposal". According to the Subdivision and Platting Act of 1973, legislative intent reveals that control of subdivision development rests in the hands of local government units, "in accordance with a comprehensive set of social, economic and environmental criteria and in compliance with detailed procedural requirements".

Titeca v. *Montana*, 634 P.2d 1156 (1981).
No public hearing is required in a preliminary enviornmental review and environmental assessment. Here, the Department of Fish, Wildlife and Parks lawfully developed and utilized the Department's property as a fishing access site.

Kadillak v. *Anaconda Co.*, 184 Mont. 127, 602 P.2d 147, 10 E.L.R. 20389 (1979).
An EIS was not required before the granting of a permit under the Hard Rock Mining Act (HRMA). If the agency decides that the action will not "significantly affect the human environment", an EIS is not necessary.

Northern Plains Resource Council v. *Board of Natural Resources & Conservation*, 181 Mont. 500, 594 P.2d 297 (1979).
The Board of natural Resources may be required to make finds as to the "nature and Economics of various alternatives" for the construction of a generator and electrical transmission facility. Here, it was determined that the proposed facility would have a minimum adverse environmental impact.

B. Montana Law Review Articles

Application of NEPA to Leasing of Property for Strip Mining on Reservation Lands, 35 Mont. L. Rev. 209 (1974).

Montana Land Use Law: Application of MEPA, 38 Mont. L. Rev. 109 (1977).

Chertkof v. *Department of Natural Resources*, 43 Md. App. 10, 402 A.2d 1315 (1979).
The issuance of a waterway construction permit was upheld where the record was shown to be sufficient to establish that the Board has before it substantial evidence to support its conclusion.

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VIII. Massachusetts

Mass. Ann. Laws ch 30, §§61-62H (Law. Co-op 1986).
Massachusetts Environmental Policy Act (MEPA) requires the preparation of an environmental impact report (EIR) for all proposed actions which may have an environmental impact. Subsequent to the preparation of an EIR, a draft or final EIR may be required by the Office of Environmental Affairs.

Citizens for Responsible Environmental Management v. *Attleboro Mall*, 400 Mass. 658, 511 N.E.2d 562, 18 E.L.R. 20118 (1987).
A proposed shopping mall is required to review its impact on wetlands and all bordering bodies of water.

Boston Preservation Alliance, Inc. v. *Secretary of Envtl. Affairs*, 396 mass. 489, 487 N.E.2d 197 (1986).
The scope of the EIR shall be limited to no more than all direct and indirect impacts from activity necessary to carry out that part of the project which is within the subject matter jurisdiction of the permit.

Marlow v. *City of New Bedford*, 369 Mass. 501, 340 N.E..2d 494 (1976).
A project to widen city streets did not require the filing of an EIR because the effective date of the environmental statute requiring an EIR occurred after work had already begun.

Secretary of Envtl' Affairs v. *Massachusetts Port Auth.*, 366 Mass. 755, 323 N.E.2d 329, 5 E.L.R. 20200 (1975).
Since a project involving the expansion of an airport did not commence until after the effective date of the environmental statute requiring an EIR, an EIR was required before construction could begin.

Conservation Law Found. of New England, Inc. v. *Director of Div. of Water Pollution Control*, 22 Mass. App. Ct. 544, 495 N.E.2d 848 (1986).
Where a part of the Massachusetts Historical Commission Act, which requires the determination of the Commission of adverse effects of a new development project, is ambiguous, the act can be construed to require only that portion of the project that is subject to State permitting.

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IX. Michigan

Executive Order 1974-4 requires each state agency to prepare a formal environmental assessment for all major activities of the agency having a possible significant impact on the environment or human life.

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Of Crabbed Interpretations and Frustrated Mandates: The Effect of Environmental Policy Acts on Pre-Existing Agency Authority, 41 Mont. L. Rev. 177 (1980).

The Public Trust: A sovereign's Ancient Prerogative Becomes the People's Environmental Right, 195 U.C.D. L. Rev. 14 (1981).

Symposium The Montana Constitution: Taking Rights Seriously, Part I, Environmental Rights, 39 Mont. L. Rev. 221 (1978).

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XII. New Jersey

While New Jersey does not have a statewide EIS process requirement, the application for various permits may trigger preparation of an EIS. If a project is to cost one million dollars of more, is to be sited in an environmentally sensitive area and has applied for State funding, an environmental assessment document must be prepared. New Jersey's Exec. Order No. 53 (1973) requires all state agencies and departments to submit to the Department of Environmental Protection a description of the enviornmental impact of all major construction projects.

Borough of Kenilworth v. *Department of Transp.*, 151 N.J. Super. 322, 376 A.2d 1266 (App. Div. 1977).
Under the New Jersey Action Plan developed by the Department of Transportation, a highway-widening project, determined by the Federal Highway Administration to be a "non-major federal action", was exempt from the EIS process.

Public Interest Research Group of New Jersey, Inc. v. *State Dept of Envtl. Protection*, 152 N.J. Super. 191, 377 A.2d 915 (app. Div. 1977)
The issuance of a permit to construct a nuclear plant for the generation of electricity was affirmed despite unresolved questions as to the ultimate solution of the environmental effect of salt emissions from the cooling towers.

South Brunswick v. *New Jersey Turnpike Auth.*,129 N.J. Super. 126, 322 A.2d 478 (App. Div. 1974).
The guidelines issued by the New Jersey Commissioner of Environmental Protection state that the "EIS provides information as to effects upon the environment, that the impacted corridor area to be studied in detail shall be of sufficient width to encompass al of the alternatives considered and that there be included a description and evaluation of each alternative right-of-way". Here, an EIS was required for the extension to the turnpike.

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XIII. New York

N.Y. Envtl. Conserv. Law §§8-0101 to 8-0117 (McKinney 1984).
New York's "Little NEPA" is called "SEQRA". The environmental review process is triggered when there is a State action, proposed or approved, which may have a significant effect upon the environment. Generally, SEQRA is tied together with the State's permitting process and required that applicants mitigate environmental impacts to the maximum extent possible.
Regulations: N.Y. Admin. Code. tit. 6, part 617.

A. Threshold Question: Decision to Prepare an EIS

Onondaga Landfill Systems. Inc. v. *Flacke*, 81 A.D.2d 1022, 440 N.Y.S.2d 788 (4th Dept. 1981).
An action involving a mining permit required the preparation of an EIS. A court may not substitute its own judgment for that of an agency where there is a rational basis for a positive declaration.

H.O.M.E.S. v. *New York State Urban Dev. Corp.*, 69 A.D.2d 222, 418 N.Y.S.2d 827 (4th Dept. 1979).
An EIS was required for the construction of the Syracuse Dome sports facility, as it was found, after a "hard Look", to have a significant environmental impact. The Urban Development Corporation and the Syracuse City Planning Commission were held to be agencies within the meaning of SEQRA. The proposed stadium was an "action" as defined in Environmental Conservation Law 8-0105.

Tri-County Taxpayers Ass'n. Inc. v. *Town Bd. of Town of Queensbury*,55 N.Y.2d 41, 447 N.Y.S.2d 699 (1982).
Prior to the adopting of a town resolution which would establish a sewer district as part of a larger county system, the town board must prepare an EIS.

City of Glens Falls v. *Board of Education*, 88 A.D.2d 233, 453 N.Y.S.2d 891 (3d Dept. 1982).
The Commissioner of Education has promulgated regulations under SEQRA which school districts must follow when proposing an actin which may have a significant effect on the environment (8NYCRR 155.5[a]). These actions include the planning, funding and/or construction of new facilities or expansion of existing structures by more than a 50 percent increase in square footage or usage where construction costs exceed $10,000 (8 NYCRR 155.5[b][1], 6 NYCRR 617.12[b][10]).

Connell v. *Town Bd. of Town of Wilmington*, 113 A.D.2d 359, 496 N.Y.S.2d 106 (3d Dept. 1985).
The adoption of a resolution by the Wilmington board to annex approximately 5,000 acres of land from a adjacent town was held not to be an "action" as defined by SEQRA.

Chinese Staff & Workers Ass'n v. *City of New York*, 68 N.Y.2d 359, 502 N.E.2d 176,509 N.Y.S.2d 499 (1986).
The regulations adopted by the City of New York (CEQR) pursuant to SEQRA requires an agency to consider potential

long-term displacement of residents and businesses in assessing environmental impact. These effects were not properly considered in a proposal to construct high-rise condominiums on a vacant lot in Chinatown.

Orchards Assoc. v. *Planning Bd. of Town of New Salem*, 114 A.D.2d 850, 494 N.Y.S.2d 760 (2d Dept. 1985), *appeal dismissed* 68 N.Y.2d 808 (1986).
A generic EIS (GEIS) is less specific than an EIS (6 NYCRR 617.15); however, when commencing a large-scale, multi-stage commercial development, a GEIS must include traffic impacts, sewage disposal an adequate storm water runoff.

B. Finding of No Significant Impact (FONSI)

Cohalan v. Carey, 88 A.D.2d 77, 452 N.Y.S.2d 639 (2d Dept. 1982), *appeal dismissed* 57 N.Y.2d 672, 439 N.E.2d 886, 454 N.Y.S.2d 77.
A negative declaration or FONSI was upheld where the Department of Correctional Services sought to convert three buildings which were part of a psychiatric center into a medium security correctional facility.

Schenectady Chemicals, Inc. v. *Flacke*, 83 A.D.2d 460, 446 N.Y.S.2d 418 (3d Dept. 1981).
The Department which issued a negative declaration concerning the proposed mining of a gravel pit failed to consider the effect that the mining would have on the quantity and quality of the area's water.

Tehan v. *Scrivani*, 97 A.D.2d 769, 468 N.Y.S.2d 402 (2d Dept. 1983)
An agency must identify relevant areas of environmental concern, take a hard look at them and make a "reasoned elaboration of the basis for its declaration of environmental insignificance".

C. Scoping

Webster Assoc. v. Town of Webster, 85 A.D.2d 882, 446 N.Y.S.2d 955 (4th Dept. 1981), *rev'd on other grounds* 59 N.Y.2d 220, 451 N.E.2d 189, 464 N.Y.S.2d 431 (1983).
SEQRA does not require a private developer to consider alternatives outside its control when preparing an EIS for the construction of a shopping mall.

Matter of Rye Town/King Civic Ass'n v. *Town of Rye*, 82 A.D.2d 474, 442 N.Y.S.2d 67 (2d Dept. 1981), *appeal dismissed* 56 N.Y.2d 985, 439 N.E.2d 397, 453 N.Y.S.2d 682 (1982).
Type I actions are more likely to require the preparation of an EIS. They generally include: the construction of a new non-residential facility which involves either the physical alteration of 10 acres, or a facility with more than 100,000 square feet of gross floor area constructed in a town with a population of 150,000 or less.

Coalition Against Lincoln West v. *City of New York*, 94 A.D.2d 483, 465 N.Y.S.2d 170 (1st Dept), *aff'd* 60 N.Y. 2d 805, 469 N.Y.S.2d 689 (1983).
There is no intention in either NEPA or SEQRA to require that every conceivable alternative be discussed.

Regulation:
6 NYCRR 617.12

D. Draft Environmental Impact Statement (DEIS)

Horn v. *International Business Machines Corp.*, 110 A.D.2d 87, 493 N.Y.S.2d 184 (2d Dept. 1985), *appeal denied* 67 N.Y.2d 602, 499 N.Y.S.2d 1027 (1985).
The DEIS must discuss reasonable alternatives to a proposal. When constructing a research center, the proposed must analyze zoning issues and the potential impact of the project on the surrounding community.

Glen Head-Glenwood Landing Civic Council, Inc. v. *Town of Oyster Bay*, 88 A.D.2d 484, 453 N.Y.S.2d 732 (2d Dept. 1982).
The grant of a rezoning application was annulled because the town and developer failed to comply with the EIS procedure of SEQRA.

Northeast Solite Corp. v. *Flacke*, 114 Misc. 2d 313, 451 N.Y.S.2d 633 (S. Ct., Alb. Co. 1982).
Whether a proposed actin may have a significant impact upon the environment, thus requiring the preparation of a draft EIS, is a discretionary matter for the Department of Environmental Conservation.

E. Public Comment and Hearing

Environmental Defense Fund, Inc. v. *Falcke*, 96 A.D.2d 862, 465 N.Y.S.2d 759 (2d Dept. 1983).
An Agency's determination may be rejected by a court if it is found to be arbitrary and capricious or unsupported by substantial evidence.

Tuxedo Conservation & Taxpayers' Ass'n v. *Town Bd. of Tuxedo*, 96 Misc. 2d 1, 408 N.Y.S.2d 668 (S.Ct., Orange Co. 1978), *aff'd* 69 A.D.2d 320, 418 N.Y.S.2d 638 (2d Dept. 1979).
State agencies and the public have a statutory right to a reasonable period of time in which to consider an FEIS. A reasonable extension of time for comment by interested parties may also be granted.

Sun Beach Real Estate Dev. Corp. v. *Anderson*, 98 A.D.2d 367, 469 N.Y.S.2d 964 (2d Dept. 1983).
A FEIS need not be prepared until after a final subdivision plan is complete and submitted; however, the FEIS must precede the agency's final decision to approve an action. If new information is discovered, the agency may also require the filing of a supplemental EIS.

F. Law Review Articles

Bowers, *New York's SEQRA in the Courts*, 5 Pace Envtl. L. Rev. 25 (1987).

Healy, *The Environmental Review Process in the City of New York CEQR*, 5 Pace Envtl. L. Rev. 51 (1978).

Paden, *DEC's part 617 Regulations As Amended: A Guide to the Implementation of SEQRA*, 5 Pace Envtl. L. Rev. 51 (1987).

For a comprehensive examination of SEQRA, see *Symposium on the New York State Environmental Quality Review Act*, 46 Alb. L. Rev. 1097 (1982):

Marsh, *Introduction SEQRA's Scope and Objectives*, 46 Alb. L. Rev. 1097 (1982)

Stevenson, *Early Legislative Attempts at Requiring Envionmental Assessment and SEQRA's Legislative History*, 46 Alb. L. Rev. 1114 (1982)

Robinson, *SEQRA's Siblings: Precedents from Little NEPA's in the Sister States*, 46 Alb. L. Rev. 1155 (1982).

and guidelines for the preparation of EISs have been formulated by the Environmental Quality Board.

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XVI. South Dakota

S.D. Codified Laws Ann. §§34A-9-1 to 34A-9-12.

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XVII. Virginia

Va. Code §§10-17.107 to 10-17.112
Environmental Impact Reviews (EIR) must be prepared for State projects which cost $100,000 or more, except for road and highway projects. The Council on the Environment is responsible of the coordination of the EIR process. Reviewing agencies are predominantly housed in the Bureau of Natural Resources. See Procedures Manual and Guidelines for the EIS Program in the Commonwealth of Virginia.

Skaggs Rudder v. *Wise County Redev. & Housing Auth.*, 219 Va. 592, 249 S.E.2d 177 (1978).
An EIS was not required or the condemnation of property within an area undergoing redevelopment by a neighborhood redevelopment authority.

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XVIII Utah

State of Utah Exec. Order (Aug. 27, 1974)

XIX. Washington

Wash. Rev. Code §§43.21C.010-43.21C.910 (1974); Wash. Admin. Code R. 197-11.

Washington's State Environmental Policy Act (SEPA) applies to all major projects which require State approval or State action. Since each agency adopts its own version of the environmental regulations and has its own review staff, the process is both individualized and decentralized. The Washington Department of Energy has published a model SEPA ordinance (Wash. Admin. Code 173-8060160) for local agencies.

A. Cases

West Main Assoc. v. *Bellevue*, 49 Wash. App. 513, 742 P.2d 1266 (1987).
In order to deny a proposal under SEPA, it must be found that the proposal would result in significant adverse environmental impacts identified in the FEIS and that reasonable mitigation measures are insufficient to mitigate the identical impacts.

D.E.B.T., Ltd. v. *Board of Commissioners*, 24 Wash. App. 136, 600 P.2d 628 (1979).
A county's ordinance may provide that the Board of County Commissioners is the "responsible official" for purposes of making the threshold determination under SEPA. An EIS was required here before approval of a preliminary development plat.

Short v. *Clallam County*, 22 Wash. App. 825, 593 P.2d 821 (1979).
A decision by the Board of Commissioners requiring the preparation of an EIS for a change of use permit could be overturned by a court only if it was arbitrary and capricious.

Asarco v. *Air Quality Coalition*, 92 Wash. 2d 685, 601 P.2d 501, 10 E.L.R. 20203 (1979).
A corporation granted a variance from air emission standards pursuant to the State Environmental Policy Act, was not precluded from complying with the EIS process. The variance application was held to be a major action significantly affecting the environment.

Polygon Corp. v. *City of Seattle*, 90 Wash. 2d 59, 578 P.2d 1309, 8 E.L.R. 20561 (1978).
SEPA "confers substantive authority" to the lead agency to act on the basis of the EIS. The denial of a building permit based on the proposed buildings' adverse impact on the environment was not erroneous in view of the public policy of SEPA.

Lassila v. *City of Wenatshee*, 89 Wash. 2d 804, 576 P.2d 54 (1978).
If a determination is made of "no significant impact" under SEPA, the lead agency must then demonstrate that environmental factors were considered in a manner sufficiently within compliance of the mandates of SEPA. A "FONSI" was made in regard to a redevelopment project in a central business district.

Sisley v. *San Juan County*, 89 Wash. 2d 822, 562 P.2d 712 (1977).
The issuance of a substantial development permit to construct a commercial marina will most often require an assessment of the environmental effects of the project. If it is found that the project significantly affects the environment, an EIS must be prepared.

Marine Property Co. v. *Port of Seattle*, 88 Wash. 2d 822, 567 P.2d 1125 (1977).
The issuance of bonds, the reacquisition of property and the continued use of existing piers used for berthing ocean vessels does not affect the quality of the environment, and thus are not major actions significantly affecting the environment which require an EIS under SEPA.

Richland Homeowner's Preservation Ass'n v. *Young*, 18 Wash. APP. 405, 568 P.2d 818 (1977).
A detailed EIS was not required before the city approved the construction of an 83-unit apartment complex.

B. Treatises

Leon, C., *Major Issues Under SEPA* (Wash. State Bar Ass'n Environmental Land Use Law Section) 1983.

Settle, R., *Washington Land Use and Environmental Law and Practice* (Butterworth Legal Pubs.) 1983.

Settle, R., *The Washington State Environmental Policy Act: A Legal and Policy Analysis* (Butterworth Legal Pubs.) 1987.

Ten Years Experience With SEPA, Final Report of the Commission on Environmental Policy, 1983.

State Environmental Policy and Handbook (Wash. Dept. of Ecology) 1987.

Weiner, K., *Overview of New SEPA Rules* (Univ. of Washington School of Law).

Weinman, R., *New Rules for SEPA* (N.W. Land Use Review) April 1984.

C. Law Review Articles

Rose and Lean, *The State Environmental Policy Act of 1971 and its 1973 Amendments*, 49 Wash. L. Rev. 509 (1974).

Rogers, *The Washington Environmental Policy Act*, 60 Wash. L. Rev. 33 (1984)

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XX. Wisconsin

Wis. Stat. §1.11 (1971, Supp. 1981-1982). The Department of Natural Resources WEPA rules are found in Wis. Admin. Code NR 150.01-40.

Wisconsin's "Little NEPA" is called the Wisconsin Environmental Policy Act (WEPA). Since WEPA is modeled on NEPA, the Wisconsin Supreme Court has often relied on Federal precedent construing NEPA as persuasive authority in interpreting WEPA.

A. Cases

Milwalkee Brewers Baseball Club v. *Wisconsin Dep't of Health & Human Serv.*, 130 Wisc. 2d 56, 387 N.W.2d 245 (1986).
Increased traffic congestion has an effect on the physical environment cognizable under WEPA. A baseball club had standing to challenge the adequacy of the FEIS concerning the proposed construction of a prison near its stadium.

Wisconsin Envtl. Decade v. *Wisconsin Dep't of Natural Resources*, 115 Wis. 2d 381, 340 N.W.2d 722 (1983).
In the absence of significant impacts on natural environment, socioeconomic impacts do not trigger the EIS process.

Fox v. *Wisconsin Dep't of Health & Human Serv.*, 112 Wis. 2d 514, 334 N.W.2d 532 (1983).
Relatives of inmates currently in a State prison system did not have standing to challenge a decision that an EIS proposed for a new maximum security prison was adequate.

Holtz & Krause, Inc. v. *Wisconsin Dep't of Natural Resources*, 85 Wis. 2d 198, 270 N.W.2d 409 (1978).
The Department of Natural Resources properly prohibited landfill operations within 1,000 feet of navigable waters, and ordered closure of the site. This was found to be a valid order despite the failure to prepare an EIS.

Town of Centerville v. *Wisconsin Dep't of Natural Resources*, 142 Wis. 2d 240, 417 N.W.2d 901 (1987).
Type I actions require an EIS, while Type II actions require an Environmental Assessment (EA); however, Type II action may also require an EIS. Attachments to an EA, such as maps, departmental memoranda an other correspondence relative to the proposed project are considered part of the EA.

Wisconsin Envt'l Decade v. *Public Serv. Comm'n 79 Wis. 2d 409*, 256 N.W.2d 149 (1977).
The Wisconsin Supreme Court set forth the test for reviewing an administrative agency's decision not to prepare an EIS: whether the decision was reasonable under the circumstances. It required review of the impacts of a PSC rate increase for large volume electricity users.

B. Wisconsin Law Review Articles

Agency Decisonmaking Under Wisconsin's Environmental Policy Act, 1977 Wis. L. Rev. *111.*

Environmental Mediation as an Alternative to Litigation, 52 Wis. Bar Bull. 26 (Feb. 1979).

Toward the Abatement of Pollution of the Waters: Permitting Process, 54 Wis. Bar Bull. 20 (Oct. 1981).

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Notes and References

1. See N. Robinson (ed.), Proceedings of a Conference on the Preparation and Review of Environmental Impact Statements, New York State Bar Association, Albany, New York (1989).
2. 820 F.2d 1051 (9th Cir. 1987).
3. The Elk Creek Valley Dam construction had been commenced at the time of the injunctive relief ordered by the Circuit Court in Marsh. The case was remanded to the District Court to determine to what extent the construction project will be placed on hold during the appellate process. See Oregon Natural Defense Council v. Marsh, 677 F. Supp. 1073 (D.C. Oregon 1987).
4. 833 F.2d 810 (9th Cir. 1987).
5. 820 F.2d 1051, 1055.
6. Id.
7. 747 F.2d 1240 (9th Cir. 1984).
8. 820 F.2d 1051, 1058, 833 F.2d 810, 817.
9. Id. at n. 8. See 51 Fed. Reg. 15625 (1986) for preamble and text of amendment of worst case analysis requirement.
10. 108 S.Ct. 2869 (June 27, 1988).
11. 800 F.2d 822 (9th Cir. 1987).
12. 33 U.S.C. 1344.
13. Id. at 838, citing 40 C.F.R. §1508.20(e).
14. Id.
15. Forty Most Asked Questions Concerning CEQ's National Environmental Policy Act Regulations, Question 40, 46 Fed. Reg. 18.026, 18,038 (1981).

Ruzow, *SEQRA in the Courts*, 46 Alb. L. Rev. 1177 (1982).

Crary, *Procedural Issues Under SEQRA*, 46 Alb. L.Rev. 1211 (1982).

Gitlen, *The Substantive Impact of SEQRA*, 46 Alb. L. Rev. 1241 (1982).

Ulasewicz, *The Department of Enviornmental Conservation and SEQRA: Upholding its Mandates and Charting Parameters for the Elusive Socio-Economic Assessment*, 46 Alb. L. Rev. 1255 (1982).

Coon, *The Use of SEQRA to Achieve Broader State Land Use Policies*, 46 Alb. L. Rev. 1285 (1982).

Damsky, *SEQRA and Zoning Law's Requirement of a Comprehensive Plan*, 46 Alb. L. Rev. 1292 (1982).

Marsh, *Commentary-Unresolved Issues*, 46 Alb. L. Rev. 1298 (1982).

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XIV. North Carolina

N.C. Gen. Stat. §113 A-1 to 10 (1978).
An EIS may be prepared when there is a request for public funding, when applying for a State permit or if the project has a potential for creating an environmental impact. Initially, an environmental assessment form is prepared to determine whether a significant environmental impact will occur. If a positive declaration is made, an EIS must then be prepared. The Office of Policy and Planning disseminates the EIS for review to all affected or interested agencies.

A. Cases

Lewis v. *White*, 287 N.C. 625, 216 S.E.2d 134 (1975).
The filing of an EIS is not a condition precedent to the commencement of construction of a building for which State funds have been appropriated. Here, the substitution of an art museum for a prison was found not to adversely affect the environment.

North Carolina v. *Williams*, 53 N.C. App. 674, 281 S.E.2d 721 (1981).
No EIS was required where the State condemned property to complete a State park. The purpose of the condemnation was to protect and provide public access to a swimming hole and there were no allegations of any environmental impact from the condemnation.

Orange County v. *North Carolina Dep't of Transp.*, 46 N.C. App. 350, 265 S.E.2d 890 (1980).
The fact that the Board of Transportation's selection of a location for a proposed interstate highway was made before a final EIS was prepared did not make the selection improper. Once environmental factors "are properly taken into consideration, pursuant to prescribed procedures, governmental agencies may effect the completion of a proposed project, notwithstanding the fact that adverse environmental consequences may occur".

In re Environmental Management Comm'n, 53 N.C. App. 135, 280 S.E.2d 520 (1981).
The purpose of an EIS is to provide the responsible State agency with a useful decision-making tool.

B. North Carolina Law Review Articles

Survey of 1980 Administrative Law, 59 N.C.L. Rev. 1165 (1982).

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XV. Puerto Rico

P.R. Laws Ann. tit. 12, §§1121-1127

Puerto Rico's Environmental Public Policy Act, Law No. 9 of June 18, 1970, as amended, requires the lead agency to prepare an environmental assessment to determine whether a proposed action will have a significant impact on the environment. EISs are used to analyze the environmental effects of proposed governmental actions. Regulations to implement the Act were promulgated in 1984,

16. Id. at fn. 15, citing State of Louisiana v. Lee, 758 F.2d 1081, 1083 (5th Cir. 1985). CEQ intends to modify its guidance in this particular area of the issue of mitigation in relationship to FONSI(s).
17. 808 F.2d 1039 (4th Cir. 1987).
18. Id. at 1042.
19. Id.
20. Id. at 1043.
21. Id. at 1042.
22. 819 F.2d 294 (C.A. D.C. 1987).
23. Id. at 299.
24. Id. at 298.
25. 40 C.F.R. §1506.1(a)(2).
26. 817 F.2d 882 (C.A. D.C. 1987).
27. As explained in the decision, USDA's animal research includes six different areas of research, including genetics and breeding, nutrition, disease and insects. Id.
28. Id. at 885.
29. Id. at 887.
30. Id. In utilizing 1508.25(a)(1), the court noted that this section "sheds further light" on the issue of whether a programmatic EIS should be prepared or not. 1508.25(a)(1) specifically defines the scope of a particular EIS.
31. The court noted that if the projects were all characterized by "highly capital-intensive, concentrated confinement animal husbandry and production practices," as plaintiffs alleged, then the research activities would then be deemed to be sufficiently connected to require the preparation of a programmatic EIS. Id, n. 8.
32. CEQ discussed the "small federal handle" issue in a recent referral concerning amendments to the Army Corps of Engineers NEPA procedures. 52 Fed. Reg. 22517, 1987.
33. Ringsred v. City of Duluth, 828 F.2d 1305 (8th Cir. 1987).
34. Id. at 1308 (originally cited from NAACP v Medical Center, Inc., 584 F.2d 619, 629 (3rd Cir. 1978)
35. 26 ERC 2117 (D.C. N. Alabama 1987).
36. Id. at 2121, quoting 42 U.S.C. §4332(2).
37. Id. The Court did note that the Forest Service is not exempted from NEPA because the exemption only applies to "environmental agencies." In fact, the use of the functional equivalency exemption to NEPA by other agencies in the federal government has never withstood court challenge. See Texas Committee on Natural Resources v. Bergland, 573 F.2d 201207-208 (5th Cir. 1978). See also, Kalur v. Resor, 335 F. Supp. 1 (D. D.C. 1971).
38. Id. at 2122.
39. Id.
40. 817 F.2d 609 (10th 1987).
41. 836 F.2d 1521 (9th Cir. 1988).
42. 852 F.2d 1223 (9th Cir. 1988).
43. Id. at 1226.
44. 836 F.2d 1521, 1529 (9th Cir. 1988).
45. 717 F.2d 1409 (D.C. Cir. 1983).
46. 852 F.2d 1223, 1227 (9th Cir. 1988).
47. 836 F.2d 1521, 1530 (9th Cir. 1988).

48. 40 C.F.R. 1502.14(d) (1985).

49. 836 F.2d 1521, 1531 (9th Cir. 1988).

50. 57 U.S.L.W. 3462 (Supreme Court Doc. No. 88-905). Plaintiffs in Bob Marshall had also contended that BLM had improperly failed to give adequate consideration to the no-action alternative before the leases were issued. The court agreed, noting that even if no significant impacts were found, BLM still had the obligation to consider alternatives where there was unresolved conflicts under 42 U.S.C. §4332(2)(E). The court noted that, "while an EIS must also include alternatives to the proposed action, 42 U.S.C. §4332(2)(c)(iii) (1982), the consideration of alternatives requirement is contained in a separate subsection of the stature and therefore constitutes an independent requirement. 42 U.S.C. §4332(2)(E)." 852 F.2d 1223, 1229 (9th Cir. 1989).

51. ___F.2d. ___ (C.A. D.C. 1988). The court also considered the plaintiffs' contention that the Department of the Interior was required to include in its alternatives section an analysis of various conservation policies as a partial alternative to the 5 year plan. The court held that the agency must make that analysis due to NEPA's goal of supplying information to decision makers but that a general discussion of conservation policies discussed in a referenced document met that goal. Id.

52. 427 U.S. 390, 410 (1976).

53. ___F.2d ___ (C.A. D.C. 1988), citing 40 C.F.R. 1508.25(a).

54. Id.

55. Id.

56. 842 F.2d 1063 (9th Cir. 1988).

57. 40 C.F.R. 1508.7.

58. Id. at 1072.

59. The court issued a second opinion in which it held that the appropriate remedy, when an agency issues a license for construction of a hydroelectric power plant without preparing an environmental assessment, was suspension of the license until the requirements of NEPA were met. LaFlamme v. Federal Energy Regulatory Commission, 852 F.2d 389 (9th Cir. 1988).

60 836 F.2d 760 (2nd Cir. 1988).

61. Id. at 762.

62. Id. at 763.

63. Id.

64. Id.

65. 819 F.2d 294 (D.C. Cir. 1987). This decision is reviewed in the 1987 case law section at ___.

66. Id. at 764.

67. Id.

68. 808 F.2d 1039 (4th Cir. 1987).

69. 808 F.2d 1039, 1043 (4th Cir. 1987). The Gilchrist court had cited a CEQ regulation, 40 C.F.R. §1506.1(a)(2), for the proposition that this was the proper analysis required for segmentation cases.

70. Id.

71. 840 F.2d 714 (9th Cir. 1988).

72. Id. at 720.

73. 753 F.2d 754 (9th Cir. 1985).

74. 840 F.2d 714, 720 (9th Cir. 1988).

75. Id. at 721.

76. Id. at 718, citing 40 C.F.R. 1502.5.

77. Id. at 718-719.
78. 855 F.2d 1380 (9th Cir. 1988).
79. Id. at 1384.
80. Id. at 1384.
81. Id. at 1385.
82. 454 U.S. 139, 143 (1981).
83. 555 F.2d 817 (D.C. Cir. 1977).
84. 855 F.2d 1380, 1384 (9th Cir. 1988).
85. 621 F.2d 1017 (9th Cir. 1980).
86. Id. at 1386.
87. Id.
88. 859 F.2d 156 (D.C Cir. 1988).
89. 33 U.S.C. §1251 et seq. (1982).
90. 33 U.S.C. §1371(C). The court notes that this is the only action under the Clean Water Act that is subject to NEPA. Id. at 167. The courts have granted EPA a "functional equivalency" exemption to NEPA requirements where the action is covered by a law providing for procedures that are substantively equivalent to NEPA. See e.g. Ethyl corp. v. Environmental Protection Agency, 541 F.2d 1 (D.C. Cir. 1973), Portland Cement Association v. Ruckelshaus, 486 F.2d 375 (D.C. Cir. 1973). However, use of the functional equivalency exemption to NEPA by other agencies in the federal government has never withstood court challenge. See Texas Committee on Natural Resources v. Bergland, 573 F.2d 201 (5th Cir. 1978).
91. 859 F.2d 156 (D.C. Cir. 1988).
92. 859 F.2d 156, 168 (D.C. Cir. 1988).
93. Id. at 169.
94. Id.
95. Id.

Appendix C

Environmental Trends

The statistical tables included in this report as Appendix C present in tabular form all of the data that will appear as graphs and charts in *Environmental Trends*, a Council on Environmental Quality report currently in galley, as well as updates of tables for which 1987 data are available. Accordingly, the following statistical tables are numbered to coincide with the format of that report, which will consist of nine chapters. However, since some of the graphic material to be presented in that report consist of maps and other illustrations, not all figures are accompanied by statistical tables; in these cases, the figure number and title appear in the table of contents for this appendix without the corresponding table. The user should be aware that the omission of some tables from the expected numerical order is not an error; rather, all tables in Appendix C are numbered to match corresponding figures in *Environmental Trends*. Researchers will thus be able to confirm environmental trends information depicted in that report by consulting this appendix. Finally, it should be noted that the numerical sequence of the tables and figures in this appendix varies somewhat from the sequence followed in *Environmental Quality 1986* because the corresponding figures sequence in *Environmental Trends* changed during the production stage of that report.

The statistical series presented herein have been taken from data available through government agencies, private studies, or the literature of various federal agencies and departments participating in the preparation of *Environmental Trends*. It should be noted that the series published herein replaces that published in *Environmental Quality 1986* where data and citations have been updated, corrected, or revised. National data are used whenever possible, with breakdowns shown only when especially meaningful.

The data appearing in the statistical tables are final except where noted as preliminary. Unless otherwise indicated, the symbols and abbreviations appearing on the statistical tables are defined as follows:

p	preliminary
c	corrected
r	revised
NA	not available
ppm	parts per million
ug/m^3	micrograms per cubic meter

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Table 1-4.
Domestic mine ore and waste production (billion metric tons), 1960-1986

Year	Metal crude ore	Metal waste	Nonmetal crude ore	Nonmetal waste
1960	0.382	0.468	1.461	0.214
1961	0.384	0.383	1.506	0.172
1962	0.383	0.400	1.497	0.204
1963	0.390	0.426	1.551	0.239
1964	0.415	0.419	1.633	0.253
1965	0.433	0.464	1.751	0.271
1966	0.454	0.582	1.823	0.336
1967	0.387	0.568	1.805	0.365
1968	0.436	0.662	1.769	0.377
1969	0.490	0.865	1.887	0.342
1970	0.532	0.885	1.896	0.395
1971	0.508	0.925	1.860	0.406
1972	0.523	0.980	1.905	0.381
1973	0.594	1.170	2.105	0.380
1974	0.569	1.107	2.087	0.384
1975	0.552	1.070	1.805	0.343
1976	0.586	1.143	1.887	0.362
1977	0.512	0.953	1.996	0.434
1978	0.570	0.925	2.186	0.519
1979	0.611	1.234	2.214	0.535
1980	0.542	1.080	1.941	0.562
1981	0.611	0.971	1.107	0.535
1982	0.391	0.625	0.816	0.334
1983	0.387	0.512	1.025	0.141
1984	0.432	0.566	0.998	0.260
1985	0.416	0.461	1.198	0.410
1986	0.426	0.564	1.052	0.345

Source: U.S. Department of the Interior, Bureau of Mines. 1974 Minerals Yearbook, Vol. 1, Metals, minerals, and fuels, table 1, p. 71. Washington, D.C.

U.S. Department of the Interior, Bureau of Mines. 1977 Minerals Yearbook, Vol. 1, Metals, minerals, and fuels, table 1, p. 42. Washington, D.C.

U.S. Department of the Interior, Bureau of Mines. 1980 Minerals Yearbook, Vol. 1, Metals, minerals, and fuels, table 1, p. 9. Washington, D.C.

U.S. Department of the Interior, Bureau of Mines. 1984 Minerals Yearbook, Vol. 1, Metals, minerals, and fuels, table 1, p. 19. Washington, D.C.

U.S. Department of the Interior, Bureau of Mines. Mining and quarrying trends in metals and industrial minerals industries, table 1, p. 19. 1986 Minerals Yearbook. Washington, D.C.

Note: Data for 1986 are from the 1987 Mineral Yearbook (in prep).

Table 1-5.
Lead production (thousand metric tons), 1900-1987

Year	Domestic mine production	Year	Domestic mine production	Year	Domestic mine production
1900	245.90	1930	506.48	1960	223.80
1901	245.60	1931	367.10	1961	237.59
1902	244.80	1932	265.81	1962	215.00
1903	255.80	1933	247.39	1963	229.88
1904	278.50	1934	260.70	1964	259.45
1905	273.97	1935	300.37	1965	273.15
1906	317.70	1936	338.29	1966	297.01
1907	340.20	1937	421.70	1967	287.49
1908	305.20	1938	335.39	1968	325.80
1909	381.10	1939	375.57	1969	461.76
1910	358.60	1940	414.95	1970	518.73
1911	400.20	1941	418.58	1971	524.90
1912	414.90	1942	450.20	1972	561.55
1913	453.80	1943	411.23	1973	547.03
1914	474.40	1944	378.20	1974	602.30
1915	509.50	1945	354.60	1975	563.80
1916	565.20	1946	304.30	1976	553.00
1917	590.50	1947	348.60	1977	537.50
1918	527.70	1948	354.20	1978	529.70
1919	402.50	1949	371.86	1979	525.60
1920	450.69	1950	390.82	1980	550.40
1921	376.03	1951	352.10	1981	445.50
1922	433.27	1952	353.98	1982	512.50
1923	496.41	1953	310.80	1983	449.30
1924	540.70	1954	295.20	1984	322.70
1925	620.88	1955	306.70	1985	414.00
1926	620.42	1956	320.05	1986	339.80
1927	603.73	1957	306.81	1987	311.30
1928	568.90	1958	242.58		
1929	587.86	1959	231.88		

Source: U.S. Department of the Interior, Bureau of Mines. 1988. U.S. salient lead statistics, primary production (data compiled by W. Woodbury). Minerals Yearbook, annual issues. Washington, D.C.

Note: Recovered from domestic ores 1900-1906 and recoverable mine production 1907-1986. Except for 1980, the United States has been a significant net importer of lead metal since 1940.

Table 1-6.
Zinc production (thousand metric tons), 1900-1987

Year	Domestic mine production	Year	Domestic mine production	Year	Domestic mine production
1900	112.40	1930	540.14	1960	394.99
1901	127.73	1931	372.22	1961	421.30
1902	142.34	1932	258.73	1962	458.58
1903	144.42	1933	348.63	1963	480.17
1904	169.37	1934	397.98	1964	521.54
1905	134.83	1935	469.83	1965	554.47
1906	201.10	1936	522.18	1966	519.45
1907	229.52	1937	568.26	1967	498.41
1908	212.37	1938	468.74	1968	480.26
1909	274.33	1939	529.61	1969	501.76
1910	294.29	1940	603.37	1970	484.53
1911	300.73	1941	679.57	1971	456.31
1912	349.81	1942	696.72	1972	433.63
1913	375.39	1943	675.13	1973	434.54
1914	377.21	1944	651.90	1974	498.00
1915	533.52	1945	557.37	1975	468.00
1916	637.93	1946	521.45	1976	483.00
1917	647.37	1947	578.42	1977	448.00
1918	577.06	1948	571.53	1978	333.00
1919	497.86	1949	538.14	1979	294.00
1920	532.97	1950	565.54	1980	348.00
1921	232.78	1951	617.97	1981	343.00
1922	428.19	1952	604.19	1982	303.00
1923	554.02	1953	496.59	1983	275.00
1924	578.78	1954	429.55	1984	253.00
1925	644.83	1955	466.93	1985	227.00
1926	702.71	1956	491.97	1986	203.00
1927	651.81	1957	482.35	1987	217.00
1928	630.67	1958	373.76		
1929	657.26	1959	385.83		

Source: U.S. Department of the Interior, Bureau of Mines. Minerals Yearbook. 1978-1979; 1984-1986 (data compiled by J.H. Jolly). Washington, D.C.

Note: Data for 1987 are from the 1987 Minerals Yearbook (in prep).

Table 1-11.
Iron ore production (million metric tons), 1900-1987

Year	Domestic mine production	Year	Domestic mine production	Year	Domestic mine production
1900	27.74	1930	59.35	1960	90.04
1901	29.06	1931	31.63	1961	71.93
1902	35.87	1932	10.01	1962	72.54
1903	35.36	1933	17.83	1963	74.41
1904	27.94	1934	24.98	1964	85.32
1905	43.08	1935	31.03	1965	89.25
1906	48.52	1936	49.57	1966	90.79
1907	52.55	1937	73.25	1967	91.20
1908	36.56	1938	28.90	1968	86.63
1909	52.12	1939	52.56	1969	88.97
1910	57.93	1940	74.88	1970	90.35
1911	44.58	1941	93.89	1971	81.33
1912	56.03	1942	107.22	1972	76.33
1913	62.97	1943	102.87	1973	88.78
1914	42.10	1944	95.63	1974	85.21
1915	56.42	1945	89.79	1975	79.64
1916	76.37	1946	71.98	1976	80.55
1917	76.50	1947	94.59	1977	56.12
1918	70.78	1948	102.62	1978	82.44
1919	61.94	1949	86.30	1979	86.78
1920	68.69	1950	99.03	1980	70.73
1921	29.96	1951	117.80	1981	74.35
1922	47.89	1952	98.88	1982	36.00
1923	70.46	1953	119.26	1983	38.16
1924	55.14	1954	78.53	1984	52.09
1925	62.90	1955	103.94	1985	49.53
1926	68.71	1956	98.87	1986	39.49r
1927	62.73	1957	107.77	1987	47.57
1928	63.20	1958	68.45		
1929	74.20	1959	60.85		

Source: Bureau of the Census. 1976. Historical statistics of the United States: Colonial times to 1970, series M 205. Washington, D.C.

U.S. Department of the Interior, Bureau of Mines. 1979. Minerals in the U.S. economy: Ten-year supply profiles for mineral and fuel commodities, p. 43. Washington, D.C.

U.S. Department of the Interior, Bureau of Mines. 1986. Ferrous metals supply/demand data, 1974-1984, p. 11. Washington, D.C.

U.S. Department of the Interior, Bureau of Mines. 1987. Mineral commodity summaries. p. 78. Washington, D.C.

Note: Data for 1987 are from 1987 Minerals Yearbook (in prep).

Table 1-12.
Nickel production (million metric tons), 1950-1987

Year	Domestic mine production	Year	Domestic mine production	Year	Domestic mine production
1950	0.83	1963	10.37	1976	12.58
1951	0.69	1964	11.05	1977	11.70
1952	0.57	1965	12.26	1978	10.25
1953	0.55	1966	12.01	1979	10.61
1954	0.75	1967	13.26	1980	10.18
1955	3.45	1968	13.83	1981	9.35
1956	6.10	1969	14.34	1982	3.14
1957	9.14	1970	14.11	1983	0.00
1958	10.65	1971	14.20	1984	8.71
1959	10.53	1972	14.27	1985	4.73
1960	12.98	1973	12.61	1986	1.50
1961	10.14	1974	12.78	1987	0.00
1962	10.18	1975	13.01		

Source: Bureau of the Census. 1976. Historical statistics of the United States: Colonial times to 1970, series M 231. Washington, D.C.

U.S. Department of the Interior, Bureau of Mines. 1979. Minerals in the U.S. economy: Ten-year supply profiles for mineral and fuel commodities, p. 57. Washington, D.C.

U.S. Department of the Interior, Bureau of Mines. 1986. Ferrous metals supply/demand data, 1974-1984, p. 19. Washington, D.C.

U.S. Department of the Interior, Bureau of Mines. 1987. Mineral commodity summaries, p. 108. Washington, D.C.

Note: Data for 1987 are from 1987 Minerals Yearbook (in prep).

Table 1-13.
Sand and gravel production (billion metric tons), 1902-1987

Year	Domestic mine production	Year	Domestic mine production	Year	Domestic mine production
1902	0.002	1931	0.139	1960	0.644
1903	0.002	1932	0.109	1961	0.682
1904	0.010	1933	0.098	1962	0.705
1905	0.021	1934	0.106	1963	0.746
1906	0.030	1935	0.112	1964	0.788
1907	0.038	1936	0.162	1965	0.824
1908	0.034	1937	0.172	1966	0.848
1909	0.054	1938	0.164	1967	0.823
1910	0.063	1939	0.205	1968	0.832
1911	0.061	1940	0.216	1969	0.850
1912	0.062	1941	0.262	1970	0.856
1913	0.072	1942	0.276	1971	0.835
1914	0.072	1943	0.212	1972	0.828
1915	0.069	1944	0.177	1973	0.892
1916	0.081	1945	0.177	1974	0.795
1917	0.069	1946	0.231	1975	0.691
1918	0.056	1947	0.261	1976	0.776
1919	0.064	1948	0.290	1977	0.815
1920	0.074	1949	0.289	1978	0.874
1921	0.072	1950	0.336	1979	0.858
1922	0.086	1951	0.363	1980	0.692
1923	0.127	1952	0.395	1981	0.626
1924	0.142	1953	0.400	1982	0.539
1925	0.156	1954	0.505	1983	0.594
1926	0.166	1955	0.537	1984	0.702
1927	0.179	1956	0.568	1985	0.726
1928	0.190	1957	0.574	1986	0.801
1929	0.202	1958	0.621	1987	0.813
1930	0.179	1959	0.662		

Source: Bureau of the Census. 1976. Historical statistics of the United States: Colonial times to 1970, series M 193. Washington, D.C.

U.S. Department of the Interior, Bureau of Mines. 1979. Minerals in the U.S. economy: Ten-year supply profiles for mineral and fuel commodities, p. 75. Washington, D.C.

U.S. Department of the Interior, Bureau of Mines. 1986. Industrial minerals supply/demand data, 1974-1984, p. 67. Washington, D.C.

U.S. Department of the Interior, Bureau of Mines. 1987. Mineral commodity summaries, p. 136. Washington, D.C.

U.S. Department of the Interior, Bureau of Mines. 1988. Preprint from the 1987 Minerals Yearbook, p. 1. Washington, D.C.

Table. 1-14.
Crushed stone production (billion metric tons), 1920-1987

Year	Domestic mine production	Year	Domestic mine production	Year	Domestic mine production
1920	0.071	1943	0.155	1966	0.738
1921	0.058	1944	0.141	1967	0.713
1922	0.073	1945	0.139	1968	0.742
1923	0.094	1946	0.162	1969	0.781
1924	0.094	1947	0.188	1970	0.787
1925	0.105	1948	0.205	1971	0.793
1926	0.113	1949	0.203	1972	0.834
1927	0.124	1950	0.229	1973	0.961
1928	0.121	1951	0.259	1974	0.945
1929	0.128	1952	0.274	1975	0.817
1930	0.115	1953	0.278	1976	0.816
1931	0.089	1954	0.374	1977	0.865
1932	0.064	1955	0.428	1978	0.953
1933	0.064	1956	0.460	1979	0.998
1934	0.084	1957	0.484	1980	0.893
1935	0.075	1958	0.486	1981	0.792
1936	0.119	1959	0.530	1982	0.717
1937	0.121	1960	0.560	1983	0.782
1938	0.113	1961	0.555	1984	0.867
1939	0.134	1962	0.596	1985	0.928
1940	0.139	1963	0.624	1986	0.928r
1941	0.166	1964	0.658	1987	1.089
1942	0.178	1965	0.708		

Source: Bureau of the Census. 1976. Historical statistics of the United States: Colonial times to 1970, series M 194. Washington, D.C.

U.S. Department of the Interior, Bureau of Mines. 1979. Minerals in the U.S. economy: Ten-year supply profiles for mineral and fuel commodities, p. 81. Washington, D.C.

U.S. Department of the Interior, Bureau of Mines. 1986. Industrial minerals supply/demand data, 1974-1984, p. 75. Washington, D.C.

U.S. Department of the Interior, Bureau of Mines. 1987. Preprint from the 1986 Minerals Yearbook, p. 1. Washington, D.C.

Note: Data from 1987 are from the 1987 Minerals Yearbook (in prep).

Table 1-15.
Asbestos production (thousand metric tons), 1900-1987

Year	Domestic mine production
1900	0.956
1901	0.678
1902	0.912
1903	0.805
1904	1.343
1905	2.820
1906	1.538
1907	0.592
1908	0.849
1909	2.799
1910	3.350
1911	6.898
1912	3.994
1913	0.998
1914	1.131
1915	1.570
1916	1.342
1917	1.527
1918	0.728
1919	1.598
1920	1.495
1921	0.754
1922	0.061
1923	0.206
1924	0.272
1925	1.141
1926	1.232
1927	2.704
1928	2.031
1929	2.862
1930	3.848
1931	2.928
1932	3.229
1933	4.305
1934	4.615
1935	8.092
1936	10.037
1937	10.958
1938	9.471
1939	14.024
1940	18.198
1941	22.127
1942	14.044
1943	5.456
1944	6.048
1945	11.091
1946	12.769
1947	21.804
1948	33.649
1949	39.360
1950	38.495
1951	46.852
1952	48.865
1953	49.402
1954	43.201
1955	40.442
1956	37.478
1957	39.601
1958	39.897
1959	41.240
1960	41.026
1961	47.912
1962	48.253
1963	60.424
1964	91.709
1965	107.297
1966	114.305
1967	111.584
1968	109.769
1969	114.305
1970	113.398
1971	118.841
1972	119.748
1973	136.078
1974	99.000
1975	89.489
1976	104.873
1977	92.256
1978	93.097
1979	93.354
1980	80.079
1981	75.618
1982	63.515
1983	69.906
1984	57.422
1985	57.457
1986	51.437
1987	50.600

Source: U.S. Department of the Interior, Bureau of Mines. U.S. salient asbestos statistics (data compiled by R.L. Virta). Washington, D.C.

U.S. Department of the Interior, Bureau of Mines. 1979. Minerals in the U.S. economy: Ten-year supply profiles for mineral and fuel commodities, p. 10. Washington, D.C.

U.S. Department of the Interior, Bureau of Mines. 1986. Industrial minerals supply/demand data, 1974-1984, p. 5. Washington, D.C.

U.S. Department of the Interior, Bureau of Mines. 1987. Mineral commodity summaries, p. 14. Washington, D.C.

U.S. Department of the Interior, Bureau of Mines. 1988. Preprint from the 1987 Minerals Yearbook, p. 1. Washington, D.C.

Table 1-16.
Phosphate rock production (million metric tons), 1900-1987

Year	Domestic mine production
1900	1.515
1901	1.508
1902	1.514
1903	1.608
1904	1.904
1905	1.979
1906	2.115
1907	2.302
1908	2.424
1909	2.376
1910	2.698
1911	3.102
1912	3.021
1913	3.161
1914	2.778
1915	1.865
1916	2.014
1917	2.625
1918	2.531
1919	2.309
1920	4.169
1921	2.097
1922	2.457
1923	3.055
1924	2.914
1925	3.538
1926	3.261
1927	3.222
1928	3.557
1929	3.821
1930	3.989
1931	2.575
1932	1.735
1933	2.530
1934	2.880
1935	3.091
1936	3.406
1937	4.020
1938	3.799
1939	3.817
1940	4.067
1941	4.765
1942	4.718
1943	5.208
1944	5.463
1945	5.900
1946	6.971
1947	9.172
1948	8.808
1949	9.131
1950	10.418
1951	11.273
1952	11.506
1953	12.719
1954	13.253
1955	13.397
1956	14.337
1957	14.832
1958	14.994
1959	16.323
1960	17.478
1961	18.128
1962	19.366
1963	20.179
1964	22.436
1965	26.344
1966	35.420
1967	36.079
1968	37.422
1969	34.224
1970	35.143
1971	35.277
1972	37.041
1973	38.226
1974	41.437
1975	44.276
1976	44.662
1977	47.256
1978	50.037
1979	51.611
1980	54.415
1981	53.624
1982	37.414
1983	42.573
1984	49.197
1985	51.000r
1986	40.320r
1987	40.954

Source: Bureau of the Census. 1976. Historical statistics of the United States: Colonial times to 1970, series M 303. Washington, D.C.

U.S. Department of the Interior, Bureau of Mines. 1979. Minerals in the U.S. economy: Ten-year supply profiles for mineral and fuel commodities, p. 65. Washington, D.C.

U.S. Department of the Interior, Bureau of Mines. 1986. Industrial minerals supply/demand data, 1974-1984, p. 57. Washington, D.C.

U.S. Department of the Interior, Bureau of Mines. 1987. Mineral commodity summaries, p. 116. Washington, D.C.

Note: Data for 1987 are from 1987 Minerals Yearbook (in prep).

Table 1-18.
Production of domestic energy resources by source (quadrillion Btu), 1950-1987

Year	Coal	Natural gas	Crude oil & NGPL	Hydro-electric & geothermal	Nuclear	Total
1950	14.06	6.23	12.27	1.42c	0.00c	33.98
1951	14.42	7.42	13.96	1.42c	0.00c	37.22
1952	12.73	7.96	14.28	1.47c	0.00c	36.45
1953	12.28	8.34	14.73	1.41c	0.00c	36.77
1954	10.54	8.68	14.54	1.36c	0.00c	35.13
1955	12.37	9.34	15.65	1.36c	0.00c	38.73
1956	13.31	10.00	16.46	1.43c	0.00c	41.21
1957	13.06	10.61	16.47	1.52c	0.00c	41.65
1958	10.78	10.94	15.49	1.59c	0.00c	38.81
1959	10.78	11.95	16.31	1.55c	0.00c	40.60
1960	10.82	12.66	16.39	1.61c	0.01c	41.49
1961	10.45	13.10	16.76	1.66c	0.02c	41.99
1962	10.90	13.72	17.11	1.82c	0.03c	43.58
1963	11.85	14.51	17.68	1.78c	0.04c	45.85
1964	12.52	15.30	17.96	1.89c	0.04c	47.72
1965	13.06	15.78	18.40	2.06c	0.04c	49.34
1966	13.47	17.01	19.56	2.07c	0.06c	52.17
1967	13.83	17.94	20.83	2.35c	0.09c	55.04
1968	13.61	19.07	21.63	2.36c	0.14c	56.81
1969	13.86	20.45	21.98	2.66c	0.15c	59.10
1970	14.61	21.67	22.91	2.64c	0.24c	62.07
1971	13.19	22.28	22.57	2.84c	0.41c	61.29
1972	14.09	22.21	22.64	2.90c	0.58c	62.42
1973	13.99	22.19	22.06	2.90c	0.91c	62.06
1974	14.07	21.21	21.04	3.23c	1.27c	60.84
1975	14.99	19.64	20.10	3.22c	1.90c	59.86
1976	15.65	19.48	19.59	3.05c	2.11c	59.89
1977	15.76	19.57	19.78	2.41c	2.70c	60.22
1978	14.91	19.49	20.68	3.00c	3.02c	61.10
1979	17.54	20.08	20.39	3.01c	2.78c	63.80
1980	18.60	19.91	20.50	3.01c	2.74c	64.76
1981	18.38	19.70	20.46	2.88c	3.01c	64.42
1982	18.64	18.25	20.50	3.36c	3.13c	63.89
1983	17.25	16.53	20.57	3.63c	3.20c	61.19
1984	19.72	17.93	21.12	3.48c	3.55c	65.81
1985	19.33	16.91	21.23	3.14c	4.15c	64.76
1986	19.51	16.47	20.53	3.25c	4.47c	64.25
1987	20.12p	16.87p	19.82p	2.84p	4.92p	64.55p

Source: U.S. Department of Energy, Energy Information Administration. 1988. Annual energy review 1987, table 2, p. 9. DOE/EIA-0384(87). Washington, D.C.

Note: One quadrillion Btu (one "quad") equals approximately 50 million metric tons of coal, 170 million barrels of crude oil, 1 trillion cubic feet of natural gas, or 293 billion kilowatt hours converted to heat. NGPL= Natural gas plant liquids.

Table 1-19.
Domestic production of coal by rank and source (million metric tons), 1900-1987

Year	Rank				Source	
	Bituminous	Sub-bituminous	Lignite	Anthracite	Under-ground	Surface
1900	192.57	0.00	0.00	52.03	0.00	0.00
1901	204.83	0.00	0.00	61.20	0.00	0.00
1902	236.02	0.00	0.00	37.53	0.00	0.00
1903	256.45	0.00	0.00	67.67	0.00	0.00
1904	252.74	0.00	0.00	66.35	0.00	0.00
1905	285.76	0.00	0.00	70.44	0.00	0.00
1906	310.99	0.00	0.00	64.65	0.00	0.00
1907	358.05	0.00	0.00	77.64	0.00	0.00
1908	301.64	0.00	0.00	75.52	0.00	0.00
1909	344.43	0.00	0.00	73.53	0.00	0.00
1910	378.32	0.00	0.00	76.63	0.00	0.00
1911	368.16	0.00	0.00	82.05	0.00	0.00
1912	408.25	0.00	0.00	76.52	0.00	0.00
1913	433.94	0.00	0.00	83.01	0.00	0.00
1914	383.39	0.00	0.00	82.38	0.00	0.00
1915	401.46	0.00	0.00	80.72	475.04	3.59
1916	455.79	0.00	0.00	79.43	525.62	5.37
1917	500.47	0.00	0.00	90.35	577.00	7.34
1918	525.50	0.00	0.00	89.64	597.62	9.66
1919	422.54	0.00	0.00	79.90	490.94	6.93
1920	515.78	0.00	0.00	81.27	580.72	9.90
1921	377.24	0.00	0.00	82.06	450.57	6.43
1922	383.00	0.00	0.00	49.60	418.66	10.12
1923	512.06	0.00	0.00	84.66	576.52	12.88
1924	438.70	0.00	0.00	79.75	501.52	14.03
1925	471.69	0.00	0.00	56.07	508.22	16.73
1926	520.04	0.00	0.00	76.58	575.49	17.53
1927	469.61	0.00	0.00	72.65	519.75	18.62
1928	454.18	0.00	0.00	68.34	499.47	20.15
1929	485.24	0.00	0.00	66.96	530.31	20.12
1930	424.05	0.00	0.00	62.93	464.94	20.30
1931	346.55	0.00	0.00	54.10	377.87	20.63
1932	280.91	0.00	0.00	45.22	302.85	21.43
1933	302.60	0.00	0.00	44.93	323.25	21.04
1934	325.95	0.00	0.00	51.85	351.15	24.12
1935	337.74	0.00	0.00	47.31	356.01	26.18
1936	398.25	0.00	0.00	49.50	413.31	31.14
1937	404.10	0.00	0.00	47.03	413.91	33.96
1938	316.13	0.00	0.00	41.81	323.15	32.20
1939	358.13	0.00	0.00	46.70	362.53	39.19

(continued)

Table 1-26a.
Domestic energy consumption by source (quadrillion Btu), 1950-1987

Year	Coal	Natural gas	Crude oil & NGPL	Hydro-electric & geothermal	Nuclear electric	Total
1950	12.35	5.97	13.32	1.44c	0.00	33.08
1951	12.55	7.05	14.43	1.45c	0.00	35.47
1952	11.31	7.55	14.96	1.50c	0.00	35.30
1953	11.37	7.91	15.56	1.44c	0.00	36.27
1954	9.71	8.33	15.84	1.39c	0.00	35.27
1955	11.17	9.00	17.25	1.41c	0.00	38.82
1956	11.35	9.61	17.94	1.49c	0.00	40.38
1957	10.82	10.19	17.93	1.56c	0.00	40.48
1958	9.53	10.66	18.53	1.63c	*	40.35
1959	9.52	11.72	19.32	1.59c	*	42.14
1960	9.84	12.39	19.92	1.66	0.01	43.80
1961	9.62	12.93	20.22	1.68	0.02	44.46
1962	9.91	13.73	21.05	1.82	0.03	46.53
1963	10.41	14.40	21.70	1.77	0.04	48.32
1964	10.96	15.29	22.30	1.91	0.04	50.50
1965	11.58	15.77	23.25	2.06	0.04	52.68
1966	12.14	17.00	24.40	2.07	0.06	55.66
1967	11.91	17.94	25.28	2.35	0.09	57.57
1968	12.33	19.21	26.98	2.35	0.14	61.00
1969	12.38	20.68	28.34	2.67	0.15	64.19
1970	12.26	21.79	29.52	2.66	0.24	66.43
1971	11.60	22.47	30.56	2.87	0.41	67.89
1972	12.08	22.70	32.95	2.97	0.58	71.26
1973	12.97	22.51	34.84	3.05	0.91	74.28
1974	12.66	21.73	33.45	3.36	1.27	72.54
1975	12.66	19.95	32.73	3.27	1.90	70.55
1976	13.58	20.35	35.17	3.15	2.11	74.36
1977	13.92	19.93	37.12	2.59	2.70	76.29
1978	13.77	20.00	39.97	3.20	3.02	78.09
1979	15.04	20.67	37.12	3.22	2.78	78.90
1980	15.42	20.39	34.20	3.23	2.74	75.96
1981	15.91	19.93	31.93	3.23	3.01	73.99
1982	15.32	18.51	30.23	3.66	3.13	70.84
1983	15.89	17.36	30.05	4.00	3.20	70.50
1984	17.07	18.51	31.05	3.88	3.55	74.06
1985	17.48	17.83	30.92	3.56	4.15	73.94
1986	17.26	16.71	32.20	3.62	4.47	74.26
1987	18.00p	17.18p	32.63p	3.27p	4.92p	76.01p

Source: U.S. Department of Energy, Energy Information Administration. 1988. Annual energy review 1987, table 3, p.11. DOE/EIA-0384(87). Washington, D.C.

Note: NGPL=Natural gas plant liquids. *=Less than 0.005 quadrillion Btus. Data for hydroelectric and geothermal for 1960-1985 are revised by adding a column for nuclear electric.

Table 1-26b.
Domestic consumption of energy by end use sector (quadrillion Btu), 1950-1987

Year	Residential & Commercial (fossil fuels)	Industrial (fossil fuels)	Transportation (fossil fuels)	Electric utilities	Total
1950	6.65	13.28	8.38	4.70	33.08
1951	6.87	14.50	8.93	5.09	35.47
1952	6.92	14.05	8.91	5.36	35.30
1953	6.73	14.71	9.03	5.75	36.27
1954	6.92	13.67	8.82	5.80	35.27
1955	7.39	15.42	9.48	6.50	38.82
1956	7.71	15.87	9.79	6.98	40.38
1957	7.49	15.86	9.84	7.26	40.48
1958	7.99	15.14	9.95	7.22	40.35
1959	8.19	15.79	10.30	7.82	42.14
1960	8.75	16.26	10.56	8.19	43.80
1961	8.96	16.26	10.73	8.47	44.46
1962	9.45	16.83	11.18	9.03	46.53
1963	9.48	17.56	11.62	9.63	48.32
1964	9.60	18.57	11.96	10.33	50.50
1965	10.00	19.25	12.39	11.01	52.68
1966	10.47	20.11	13.05	11.99	55.66
1967	11.04	20.10	13.70	12.70	57.57
1968	11.40	20.87	14.81	13.88	61.00
1969	11.90	21.63	15.45	15.18	64.19
1970	12.14	21.94	16.04	16.27	66.43
1971	12.35	21.68	16.67	17.15	67.89
1972	12.64	22.40	17.67	18.52	71.26
1973	12.27	23.55	18.57	19.85	74.28
1974	11.77	22.63	18.08	20.02	72.54
1975	11.60	20.37	18.20	20.35	70.55
1976	12.25	21.44	19.06	21.57	74.36
1977	11.87	21.89	19.77	22.71	76.29
1978	11.91	21.86	20.56	23.72	78.09
1979	11.53	22.78	20.43	24.13	78.90
1980	10.72	21.04	19.66	24.50	75.96
1981	10.04	19.69	19.46	24.76	73.99
1982	10.06	17.45	19.03	24.26	70.84
1983	9.71	16.72	19.10	24.93	70.50
1984	10.09	18.16	19.84	25.94	74.06

(continued)

Table 1-26b. (continued)

Year	Residential & Commercial (fossil fuels)	Industrial (fossil fuels)	Transportation (fossil fuels)	Electric utilities	Total
1985	9.83	17.53	20.08	26.48	73.94
1986	9.58	17.25	20.74	26.66	74.26
1987	9.62	17.68p	21.12p	27.56p	76.01p

Source: U.S. Department of Energy, Energy Information Administration. 1988. Annual energy review 1987, table 4, p.13. DOE/EIA-0384(87). Washington, D.C.

Note: Data do not include the consumption of wood energy (other than that consumed by the electric utility industry) which amounted to 2.6 quadrillion Btu in 1984. This table also does not include small quantities of energy forms for which consistent historical data are not available, such as geothermal, waste, wood, photovotaic, or solar thermal energy sources except that consumed by electric utilities. Some of components may not equal total due to independent rounding.

Table 1-27.
World energy consumption by region (million metric tons) and per capita (kilograms), 1960-1984

Year	North America		United States		South America	
	Total	Per capita	Total	Per capita	Total	Per capita
1960	1599	5951	1454	8047	79	535
1970	2502	7825	2217	10811	143	749
1980	2796	7480	2364	10386	251	1046
1984	2688	6800	2257	9577	254	965

Year	Europe		Asia		U.S.S.R.	
	Total	Per capita	Total	Per capita	Total	Per capita
1960	1039	2443	514	276	595	2777
1970	1720	3745	903	386	999	4132
1980	2145	4433	1579	607	1473	5549
1984	2081	4244	1857	666	1594	5977

Source: Statistical Office of the United Nations. Energy statistics yearbook, annual. New York, NY. as in: Bureau of the Census. 1986. Statistical abstracts of the United States: 1987, no. 946. Washington, D.C.

Note: Data are in tons of coal equivalent. Data for North America includes Central America.

Table 1-28.
Land mined (millions of acres) and reclaimed (percentage of mined area) by selected mineral commodity, 1930-1980

Mineral Commodity	Mined acreage	Percentage reclaimed
Coal	2.700	75.4
Clays	0.230	37.4
Copper	0.188	2.9
Iron ore	0.121	4.2
Phosphate rock	0.270	24.2
Sand and gravel	0.960	30.8
Crushed stone	0.752	23.5
Other	0.467	13.1

Source: Johnson, W. & J. Paone. 1981. Land utilization and reclamation in the mining industry, 1930-1980. U.S. Department of the Interior, Bureau of Mines Information Circular 8862. Washington, D.C.

Note: Mined acreage includes area of surface mine excavation, area used for disposal of surface mine waste, surface area subsided or disturbed as a result of underground waste, and surface area used for disposal of mill or processing waste. Other mineral commodities include bauxite, beryllium, gold, lead, manganese, mercury, molybdenum, nickel, platinum-group metals, silver, titanium, tungsten, vanadium, zinc, aplite, asbestos, boron minerals, diatomite, feldspar, fluorspar, garnet, graphite, greensand marl, gypsum, kyanite, lithium minerals, magnesite, mica, millstones, olivine, perlite, potassium salts, pumice, pyrites, salt, sodium carbonate, talc, tripoli, vermiculite, wollastonite, anthracite, and peat.

Table 2-2b.
Mean annual discharge (percentage of annual runoff), Boise River near Twin Springs, Idaho, 1951-1980

Month	Runoff
October	2.65
November	2.93
December	3.40
January	3.26
February	3.64
March	5.24
April	13.99
May	25.87
June	24.15
July	8.99
August	3.32
September	2.57

Source: U.S. Department of the Interior, Geological Survey. 1986. National water summary 1985, fig. 32, p. 56, Water-Supply Paper 2300 (data compiled by K.J. Hitt, USGS). Reston, VA.

Table 2-2c.
Mean annual discharge (cubic feet per second), Middle Concho River in Texas, 1931-1968

Year	Discharge	Year	Discharge	Year	Discharge
1931	19.6	1944	20.7	1957	142.0
1932	97.0	1945	12.1	1958	58.0
1933	11.0	1946	25.0	1959	33.0
1934	2.8	1947	23.5	1960	43.0
1935	66.0	1948	55.0	1961	8.3
1936	140.0	1949	72.0	1962	0.1
1937	36.0	1950	19.0	1963	0.1
1938	16.6	1951	5.5	1964	15.2
1939	13.8	1952	3.0	1965	12.7
1940	9.0	1953	33.0	1966	28.0
1941	124.0	1954	66.0	1967	5.2
1942	40.0	1955	27.0	1968	0.3
1943	10.8	1956	16.6		

Source: Sauer, S.P. 1972. Factors contributing to unusually low runoff during the period 1962-1968 in the Concho River basin, Texas. U.S. Geological Survey Water-Supply Paper 1999-L. IN: National water summary 1985, fig. 33, p. 58, Water-Supply Paper 2300, 1986 (data compiled by K.J. Hitt, USGS). Reston, VA.

Table 2-2d.
Mean annual discharge (cubic feet per second), Red River of the North at Grand Forks, North Dakota, 1885-1986

Year	Discharge	Year	Discharge	Year	Discharge
1885	2600	1920	3053	1955	1510
1886	3500	1921	1565	1956	1941
1887	1100	1922	2220	1957	2374
1888	2400	1923	1333	1958	1860
1889	810	1924	731	1959	1072
1890	740	1925	1246	1960	1675
1891	1100	1926	1217	1961	763
1892	4600	1927	2675	1962	5404
1893	4400	1928	1795	1963	2541
1894	2300	1929	1726	1964	2013
1895	780	1930	1227	1965	4604
1896	3200	1931	351	1966	6048
1897	6000	1932	623	1967	4067
1898	1800	1933	401	1968	1844
1899	2200	1934	244	1969	5094
1900	1100	1935	439	1970	3922
1901	3900	1936	592	1971	2085
1902	3200	1937	591	1972	4949
1903	2900	1938	894	1973	1739
1904	4800	1939	579	1974	4721
1905	3501	1940	762	1975	6677
1906	4787	1941	1594	1976	2463
1907	3671	1942	2323	1977	497
1908	3164	1943	4085	1978	4337
1909	2417	1944	2719	1979	5962
1910	2819	1945	3624	1980	1948
1911	731	1946	2643	1981	1014
1912	749	1947	4329	1982	3590
1913	1350	1948	3409	1983	3756
1914	1656	1949	2121	1984	4273
1915	2897	1950	7580	1985	4428
1916	5582	1951	3680	1986	5762
1917	2702	1952	3670		
1918	965	1954	1766		

Source: U.S. Department of the Interior, Geological Survey. 1986. National water summary 1985, fig. 36. p. 59, Water-Supply Paper 2300 (data compiled by H.C. Riggs, USGS). Reston, VA.

Note: Data for 1985-1986 updated by agency.

Table 2-2e.
Peak annual discharge (cubic feet per second), North Platte River at North Platte, Nebraska, 1895-1987

Year	Discharge	Year	Discharge	Year	Discharge
1895	17400	1926	10800	1957	1980
1896	16300	1927	9200	1958	3710
1897	25000	1928	15600	1959	2100
1898	15300	1929	20900	1960	2080
1899	18300	1930	11000	1961	2050
1900	19400	1931	6900	1962	3540
1901	19400	1932	6320	1963	2490
1902	9900	1933	9980	1964	2550
1903	16000	1934	3840	1965	1900
1904	16600	1935	11700	1966	2790
1905	24000	1936	6400	1967	2500
1906	19200	1937	3900	1968	3180
1907	16000	1938	5010	1969	2170
1908	16700	1939	3920	1970	2950
1909	29600	1940	2320	1971	9580
1910	6900	1941	1580	1972	3310
1911	3550	1942	6610	1973	6930
1912	15000	1943	2430	1974	4390
1913	9040	1944	2510	1975	3000
1914	8150	1945	2650	1976	3560
1915	10900	1946	2060	1977	3170
1916	5000	1947	2630	1978	2990
1917	20900	1948	3360	1979	1720
1918	10000	1949	2580	1980	2380
1919	4300	1950	1910	1981	2560
1920	15000	1951	5390	1982	2290
1921	24100	1952	3050	1983	7800
1922	10800	1953	2500	1984	6220
1923	10500	1954	2160	1985	3030
1924	18500	1955	2160	1986	3200
1925	6300	1956	2120	1987	3460

Source: U.S. Department of the Interior, Geological Survey. 1986. National water summary 1985, fig. 67, p. 91, Water-Supply Paper 2300 (data compiled by J.E. Kircher, USGS). Reston, VA.

Note: Data for 1981-1987 updated by agency.

Table 2-3a.
Water levels in the Great Salt Lake, Utah (water surface elevation, in feet above sea level), 1850-1987

Year	Elevation	Year	Elevation	Year	Elevation
1850	4200.56	1888	4205.26	1926	4203.42
1851	4201.35	1889	4203.63	1927	4202.67
1852	4202.40	1890	4203.14	1928	4201.76
1853	4204.02	1891	4202.87	1929	4201.13
1854	4203.68	1892	4202.22	1930	4200.53
1855	4203.88	1893	4202.14	1931	4199.42
1856	4203.72	1894	4202.10	1932	4198.52
1857	4202.98	1895	4201.45	1933	4197.86
1858	4202.08	1896	4201.08	1934	4196.18
1859	4201.07	1897	4201.28	1935	4195.08
1860	4200.47	1898	4200.98	1936	4194.88
1861	4200.24	1899	4200.53	1937	4195.48
1862	4202.34	1900	4200.27	1938	4195.61
1863	4203.36	1901	4199.20	1939	4195.55
1864	4204.01	1902	4197.24	1940	4194.73
1865	4205.12	1903	4196.93	1941	4194.80
1866	4206.66	1904	4197.33	1942	4195.48
1867	4208.08	1905	4196.83	1943	4195.43
1868	4209.64	1906	4197.15	1944	4195.55
1869	4210.44	1907	4199.37	1945	4195.62
1870	4209.91	1908	4200.42	1946	4196.23
1871	4209.98	1909	4201.77	1947	4196.68
1872	4210.97	1910	4202.91	1948	4196.96
1873	4211.06	1911	4202.42	1949	4197.28
1874	4210.53	1912	4202.14	1950	4197.97
1875	4209.18	1913	4202.29	1951	4198.93
1876	4209.81	1914	4202.75	1952	4199.87
1877	4209.83	1915	4202.43	1953	4199.79
1878	4208.81	1916	4201.98	1954	4198.45
1879	4206.71	1917	4202.48	1955	4197.30
1880	4205.76	1918	4202.78	1956	4196.96
1881	4205.59	1919	4201.82	1957	4196.55
1882	4205.28	1920	4201.27	1958	4196.36
1883	4204.41	1921	4202.24	1959	4195.35
1884	4204.86	1922	4203.33	1960	4194.35
1885	4206.46	1923	4204.11	1961	4192.78
1886	4207.04	1924	4204.09	1962	4192.74
1887	4206.57	1925	4203.73	1963	4192.11

(continued)

Table 2-7c.
Point source loadings to receiving waters (millions of tons per year for TSS, BOD, and phosphorus and millions of pounds per year for metals), mid-1980s

Industry	TSS	BOD	Phosphorus	Metals
Minerals & metals	0.355	0.006	0.255	4.321r
Chemical & manufacturing	0.189r	0.109r	0.266r	2.928r
Agriculture & fisheries	0.277	0.404	92.800	0.000
POTWs	1.311r	1.352r	421.739r	1.698r
Total	2.132r	1.871r	515.315r	8.947r

Source: U.S. Environmental Protection Agency, Effluent Technology Division, unpublished data. 1979. Washington, D.C.

U.S. Environmental Protection Agency, Office of Water Regulations and Standards, Monitoring and Data Support Division. 1988. Summary of effluent characteristics and guidelines for selected industrial point source categories: Industry status sheets. Washington, D.C.

U.S. Environmental Protection Agency, Municipal Pollution Control. 1987. 1986 needs survey report to Congress--assessment of needed publicly owned wastewater treatment facilities in the United States. Washington, D.C.

U.S. Environmental Protection Agency, Office of Water Regulations and Standards. 1985. Report to Congress on the discharge of hazardous wastes to publicly owned treatment works. Washington, D.C.

Note: Mineral & metals includes aluminum forming, coal mining, copper forming, foundries, iron and steel, metal finishing, nonferrous metals mining and forming, ore mining and petroleum refining industries. Chemical & manufacturing includes battery manufacturing, coil coating, electrical and electronic components, organic and inorganic chemicals, plastics, synthetic fibers, pesticide manufacturing, pharmaceuticals manufacturing, plastics molding and forming, porcelain enameling, leather tanning, pulp and paper, and textile industries. Agriculture & fisheries includes animal feedlots, fish hatcheries, food and beverages, fruits and vegetables, meat packing, and seafood industries. POTWs=publicly owned treatment works. TSS=total suspended solids. BOD=biochemical oxygen demand. Metals=cadmium, copper, lead, mercury and zinc. Industrial loadings are direct discharges based on long-term average concentrations and total industry flows at Best Available Technology (BAT) presented in U.S. EPA (1983), except as follows: loadings for electrical and electronic components reflect current level of treatment (U.S. EPA, 1983); conventional loadings for agriculture & fisheries industries represent post-BAT treatment levels; and conventional and toxic pollutant loadings for POTWs include indirect industrial (at Pretreatment Standards for Existing Systems (PSES) discharge levels) and residential/commercial loadings not removed by the POTWs. Phosphorus loadings for POTWs represent effluent levels of 5 mg/l. POTW removal efficiencies of 82 and 78 are assumed for copper and zinc, respectively.

Table 2-7d.
Nonpoint source contributions to receiving waters by source (millions of tons), 1980

Source	TSS	BOD	Nitrogen	Phosphorus
Cropland	1870.00	9.00	4.30	1.56
Pasture and rangeland	1220.00	5.00	2.50	1.08
Forest land	256.00	0.80	0.39	0.09
Construction sites	197	NA	NA	NA
Mining sites	59	NA	NA	NA
Urban runoff	20	0.5	0.15	0.019
Rural roadways	2	0.004	0.0005	0.001
Small feedlots	2	0.05	0.17	0.032
Landfills	NA	0.3	0.026	NA
Background	1260.00	5.00	2.50	1.10
Total	4886.00	20.65	10.04	3.88

Source: Adopted from Bailey, G.W. & T.E. Waddell. 1979. Best management practices from agriculture and silvaculture: an integrated review, p. 37. IN: Best management practices for agriculture and silvaculture. Ann Arbor Science, Ann Arbor, MI.

Note: TSS=total suspended solids. BOD=biochemical oxygen demand. Excluded from the survey area are 207 million acres of public lands (14% of the contiguous United States), mostly in the Rocky Mountains, because of inadequacy of information. Urban runoff includes separate storm sewers only.

Table 2-7e.
Surface waters impacted by nonpoint sources, 1985

Status	Rivers (thousands of miles)	Lakes (millions of acres)	Estuaries (thousands of square miles)	Ocean (thousands of shore-line miles)
No use impairment	230	7.20	11.1	6.30
Threatened	48	3.70	3.0	0.10
Moderately impaired	87	3.50	1.6	0.34
Severely impaired	30	0.88	0.8	0.01
Undistinguished	9	0.09	2.5	0.07
Total assessed waters	404	15.37	19.0	6.82

Source: The Association of State and Interstate Water Pollution Control Administrators, in cooperation with the U.S. Environmental Protection Agency. 1985. America's clean water: The states' nonpoint source assessment, 1985. Washington, D.C.

Note: Does not include data for Alaska. States report there are 1.48 million river miles, 26.6 million lake acres, 32,000 estuary square miles and 23,000 ocean coastline miles.

Table 2-8a.
Changes in water quality, 1972-1982

Water quality status 1972-1982	Rivers & streams (thousands of miles)	Lakes (millions of acres)	Estuaries (thousands of square miles)
Maintained	296.00	10.13	12.80
Improved	47.00	0.39	3.80
Degraded	11.00	1.65	0.56
Unknown	90.00	4.15	0.17
Total	444.00	16.32	17.33

Source: The Association of State and Interstate Water Pollution Control Administrators, in cooperation with the U.S. Environmental Protection Agency. 1984. America's clean water: The states' evaluation of progress, 1972-1982. Washington, D.C.

Note: Does not include data for Alaska.

Table 2-8b.
River and stream miles supporting uses (thousands of miles and percentage of waters assessed), 1972-1982

Status	1972 Miles	Percent	1982 Miles	Percent
Supporting uses	272	36	488	64
Partially supporting uses	46	6	167	22
Not supporting uses	30	4	35	5
Unknown or not reported	410	54	68	9

Source: The Association of State and Interstate Water Pollution Control Administrators, in cooperation with the U.S. Environmental Protection Agency. 1984. America's clean water: The states' evaluation of progress, 1972-1982. Washington, D.C.

Note: Forty-nine (49) states reported on water quality conditions between 1972 and 1982 for 758,000 river and stream miles and 16.3 million lake acres. Some proportion of the 1972 data unknown or not reported fell into each of the levels of use support for 1982.

Table 2-8c.
Condition of perennial streams related to their ability to support fish (thousands of miles), 1977-1982

Condition (worst to best)	1977	1982
0	29.87	29.87
1	48.79	49.31
2	170.07	166.31
3	222.02	228.66
4	155.57	156.24
5	38.20	36.13

Source: U.S. Department of the Interior, Fish and Wildlife Service. 1984. 1982 national fisheries survey, vol. 1. FWS/OBS-84/06. Washington, D.C.

Table 2-10.
Detection of pesticides in stream and river water and sediment (average number of detections per 100 samples), 1975-1980

Year	Organochlorine insecticides		Organophosphate insecticides	
	In sediment	In water	In sediment	In water
1975	65.3	2.4	NA	2
1976	82.3	2.9	NA	5
1977	74.2	3.2	NA	7
1978	41.1	3.1	NA	5
1979	52.1	1.2	NA	4
1980	NA	0.9	NA	6

Source: Gilliom, R.J., R.B. Alexander & R.A. Smith. 1985. Pesticides in the Nation's rivers, 1975-1980, and implications for future monitoring, fig. 3, p. 12 & fig. 6, p. 19. U.S. Department of the Interior, Geological Survey Water-Supply Paper 2271. Reston, VA.

Table 2-11.
Estimated phosphorus loadings to the Great Lakes (metric tons), 1976-1985

Year	Lake Superior	Lake Michigan	Lake Huron	Lake Erie	Lake Ontario
1976	3550	6656	4802	18480	12695
1977	3661	4666	3763	14576	8935
1978	5990	6245	5255	19431	9547
1979	6619	7659	4881	11941	8988
1980	6412	6574	5307	14855	8579
1981	3412	4091	3481	10452	7437
1982	3160	4084	4689	12349	8891
1983	3407	4515	3978	9880	6779
1984	3642	3611	3452	12874	7948
1985	2864	3956r	5758	11216r	7083r

Source: Great Lakes Water Quality Board. Great Lakes water quality, 1976; 1977; 1981; 1983 ; 1985. Appendix B. Surveillance Subcommittee Report to the International Joint Commission, Canada and United States. Windsor, ON.

Note: The 1978 Great Lakes Water Quality Agreement set target loadings for each lake (in metric tons per year): Lake Superior, 3400; Lake Michigan, 5600; Lake Huron, 4360; Lake Erie, 11000; and Lake Ontario, 7000.

Table 2-12a.

Contaminant levels in Lake Superior and Lake Huron lake trout (parts per million in whole fish samples), 1977-1983

Year	Lake Superior		Lake Huron	
	DDT	PCB	DDT	PCB
1977	1.20	1.87	NA	NA
1978	1.02	0.93	2.19	2.92
1979	1.09c	0.88	2.85	3.66
1980	0.62	1.89	1.53	3.44
1981	0.81	1.40	1.79	3.51
1982	0.29	0.48	1.31	2.10
1983	0.23	0.71	NA	NA

Source: DeVault, D.S., W.A. Willford, R.J. Hesselberg, D.A. Nortrupt, E.G.S. Rundberg, A.K. Alwan & C. Bautista. 1986. Contaminant trends in lake trout (Salvelinus namaycush) from the Upper Great Lakes. Arch. Environ. Contam. Toxicol. 15: 349-356.

Table 2-12b.

Contaminant levels in Lake Michigan lake trout and bloaters (parts per million in whole fish samples), 1969-1984

Year	Lake trout			Bloaters		
	DDT	PCB	Dieldrin	DDT	PCB	Dieldrin
1969	NA	NA	NA	9.94	NA	0.27
1970	19.19	NA	0.27	9.87	NA	0.19
1971	13.00	NA	0.20	6.24	NA	0.27
1972	11.31	12.86	0.20	4.33	5.66	0.18
1973	9.96	18.93	0.27	2.09	5.24	0.28
1974	8.42	22.91	0.30	1.33	5.57	0.28
1975	7.50	22.28	0.35	1.27	4.54	0.39
1976	5.65	18.68	0.30	0.90	4.11	0.35
1978	4.58	8.18	0.44	0.81	3.10	0.55
1980	4.74	9.93	0.34	0.47	2.22	0.41
1982	2.74	5.63	0.21	0.59	2.13	0.43
1984	2.20	4.48	0.38	0.85	2.24	0.28

Source: Devault, D.S., W.A. Willford, R.J. Hesselberg, D.A. Nortrupt, E.G.S. Rundberg, A.K. Alwan & C. Bautista. 1986. Contaminant trends in lake trout (Salvelinus namaycush) from the Upper Great Lakes. Arch. Environ. Contam. Toxicol. 15: 349-356.

U.S. Department of the Interior, Fish and Wildlife Service, Great Lakes Fishery Laboratory, unpublished data. 1986. Ann Arbor, MI.

Table 2-12c.
Contaminant levels in Lake Michigan coho salmon (parts per million in whole fish samples), 1969-1976, and (parts per million in skin on fillets), 1980-1984

Year	Coho salmon			Year	Coho salmon		
	DDT	PCB	Dieldrin		DDT	PCB	Dieldrin
1969	11.82	NA	0.21	1980	0.62	1.93	0.06
1970	14.03	NA	0.12	1981	0.53	1.37	NA
1971	9.85	NA	0.11	1982	0.27	0.83	0.02
1972	7.17	10.93	0.13	1983	0.16	0.30	0.02
1973	4.48	12.17	0.09	1984	0.19	0.39	0.01
1974	3.82	10.45	0.10				
1975	3.25	10.77	0.10				
1976	2.98	9.21	0.08				

Source: U.S. Department of the Interior, Fish and Wildlife Service, Great Lakes Fishery Laboratory, unpublished data. 1986. Ann Arbor, MI.

DeVault, D.S., J.M. Clark, G. Lahois & J. Weishaar. 1988. Contaminants and trends in fall run coho salmon. Journal of Great Lakes Research 14: 23-33.

Table 2-12d.
Contaminant levels in Lake Erie walleye and rainbow smelt (parts per million in whole fish samples) and coho salmon (parts per million in skin on fillets), 1977-1984.

Year	Walleye			Rainbow smelt	Coho salmon		
	DDT	PCB	Dieldrin	DDT	DDT	PCB	Dieldrin
1977	0.50	1.61	0.07	0.06	NA	NA	NA
1978	0.26	1.47	0.05	0.06	NA	NA	NA
1979	0.49	3.05	0.10	0.10	NA	NA	NA
1980	0.45	1.40	0.04	0.12	0.16	1.07	0.04
1981	0.10	1.16	0.02	0.06	0.11	0.90	NA
1982	0.24	1.62	0.04	0.07	0.10	0.67	0.02
1983	0.26	1.54	0.05	0.04	0.09	0.51	0.02
1984	NA	NA	NA	NA	0.06	0.38	0.01

Source: Great Lakes Water Quality Board. 1985. 1985 report on Great Lakes water quality to the International Joint Commission, Canada and United States. Windsor, ON.

Devault, D.S., J.M. Clark, G. Lahvis & J. Weishaar. 1988. Contaminants and trends in fall run coho salmon. Journal of Great Lakes Research 14 (1): 23-33.

Table 2-12e.
Contaminant levels in Lake Ontario fishes (parts per million in whole fish samples), 1977-1983

Year	Lake trout			Rainbow smelt		
	DDT	PCB	Dieldrin	DDT	PCB	Dieldrin
1977	4.35	8.00	NA	0.60	1.50	0.02
1978	1.27	5.06	0.21	0.39	1.74	0.05
1979	1.99	4.73	0.23	0.39	0.80	0.04
1980	0.81	4.77	0.12	0.25	1.12	0.04
1981	1.51	3.67	0.19	0.49	0.90	0.06
1982	1.13	5.87	0.15	0.44	1.68	0.05
1983	1.56	6.44	0.14	0.53	1.48	0.03

Source: Great Lakes Water Quality Board. 1985. 1985 report on Great Lakes water quality to the International Joint Commission, Canada and United States. Windsor, ON.

Table 2-15a.
Harvest limited shellfish waters for selected Northeast estuaries (percentage of productive shellfish waters), 1971-1985

Year	Sheepscot Bay, MA	Merrimack River, MA	Connecticut River, CT	Narragansett Bay, RI
1971	48	100	100	29
1974	48	100	100	30
1980	44	100	100	32
1985	43	100	100	34

Year	Saco Bay, NH	Great South Bay, MA	Barnegat Bay, NJ	Delaware Bay, DE
1971	19	12	17	14
1974	19	12	19	15
1980	20	25	24	15
1985	23	24	24	15

Source: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Ocean Survey, Ocean Assessments Division, Strategic Assessment Branch. 1986. Trends in harvest limited shellfish areas by estuary (data compiled from the National Estuarine Inventory database). Rockville, MD.

Table 2-15b.
Harvest limited shellfish waters for selected Southeast estuaries (percentage of productive shellfish waters), 1971-1985

Year	Charleston Harbor, SC	Cape Fear River, NC	Santee River, GA	Broad River, SC
1971	100	NA	71	15
1974	100	88	71	15
1980	100	88	61	9
1985	100	67	59	12

Source: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Ocean Survey, Ocean Assessments Division, Strategic Assessment Branch. 1986. Trends in harvest limited shellfish areas by estuary (data compiled from the National Estuarine Inventory database). Rockville, MD.

Table 2-15c.
Harvest limited shellfish waters for selected Gulf coast estuaries (percentage of productive shellfish waters), 1971-1985

Year	Mobile Bay, AL	Matagorda Bay, TX	Corpus Christi Bay, TX	Galveston Bay, TX
1971	100	8	21	NA
1974	100	11	21	21
1980	100	11	21	51
1985	100	12	24	51

Source: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Ocean Survey, Ocean Assessments Division, Strategic Assessment Branch. 1986. Trends in harvest limited shellfish areas by estuary (data compiled from the National Estuarine Inventory database). Rockville, MD.

Table 2-15d.
Harvest limited shellfish waters for selected Pacific Northwest estuaries (percentage of productive shellfish waters), 1971-1985

Year	Coos Bay, OR	Willapa Bay, WA	Puget Sound, WA	Grays Harbor, WA
1971	87	3	35	24
1974	72	3	36	58
1980	73	3	35	24
1985	73	3	38	100

Source: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Ocean Survey, Ocean Assessments Division, Strategic Assessment Branch. 1986. Trends in harvest limited shellfish areas by estuary (data compiled from the National Estuarine Inventory database). Rockville, MD.

Table 2-16a.
PCBs and PAHs in sediments from selected estuaries (parts per billion), 1984-1985

Estuary	Total PCBs		Total PAHs	
	1984	1985	1984	1985
Casco Bay, ME	95.28	77.55	7320.00	1966.04
Merrimack River, MA	52.97	29.23	1730.00	767.53
Salem Harbor, MA	533.58	403.10	10220.00	12828.36
Boston Harbor, MA	17104.86	736.00	26440.00	34262.02
Buzzards' Bay, MA	308.46	192.15	1710.00	1024.72
Narragansett Bay, RI	159.96	220.60	2350.00	2253.82
East Long Island Sound, NY	10.00	8.62	48560.00	106.24
West Long Island Sound, NY	234.43	174.31	8430.00	4397.45
Raritan Bay, NJ	443.89	529.28	5010.00	5439.86
Delaware Bay, DE	2.50	130.67	330.00	616.04
Lower Chesapeake Bay, VA	51.00	39.74	410.00	391.82
Pamlico Sound, NC	ND	ND	219.25	241.54
Charleston Harbor, SC	9.10	8.43	802.98	1564.86
Sapelo Sound, GA	ND	0.00	22.28	115.80
St. Johns River, FL	140.00	120.04	1926.91	1600.48
Charlotte Harbor, FL	ND	ND	26.51	32.97
Tampa Bay, FL	ND	ND	27.10	64.93
Apalachicola Bay, FL	12.00	11.93	200.25	121.17
Mobile Bay, AL	ND	ND	96.79	159.85
Round Island, MS	ND	ND	52.36	75.89
Mississippi River Delta, LA	34.00	30.14	603.41	639.39
Barataria Bay, LA	ND	ND	106.08	187.51
Galveston Bay, TX	ND	ND	68.05	55.71
San Antonio Bay, TX	ND	ND	8.98	26.65
Corpus Christi Bay, TX	ND	ND	28.17	192.36
Lower Laguna Madre, TX	ND	ND	0.00	34.77
San Diego Harbor, CA	422.10	531.67	5000.00	5938.50
San Diego Bay, CA	6.74	9.30	0.00	91.38
Dana Point, CA	7.06	5.74	22.87	13.86
Seal Beach, CA	46.71	46.47	257.96	258.30
San Pedro Canyon, CA	159.56	176.90	527.00	805.33
Santa Monica Bay, CA	14.00	13.69	68.25	38.75
San Francisco Bay, CA	123.46	NA	5976.03	NA
Bodega Bay, CA	4.18	4.89	11.00	44.00
Coos Bay, OR	3.19	6.60	234.67	390.33
Columbia River Mouth, OR/WA	8.77	6.73	145.03	81.33
Nisqually Reach, WA	4.23	4.28	0.00	6.33
Commencement Bay, WA	20.60	20.50	1200.00	1213.33
Elliott Bay, WA	329.87	414.50	4700.00	4602.33
Lutak Inlet, AK	5.50	5.80	0.00	0.00
Nahku Bay, AK	6.60	5.08	100.00	76.50

Source: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Ocean Service, Ocean Assessments Division. 1988. National Status and Trends Program for Marine Environmental Quality. A summary of selected data on chemical contaminants in sediments collected during 1984, 1985, 1986, and 1987. Rockville, MD.

Note: PCBs=Polychlorinated biphenyls; PAHs=Polycyclic aromatic hydrocarbons. ND= Not detected

Table 2-16b.
Clostridium perfringens in sediments from selected estuaries (cells per gram) 1984-1985

Estuary	1984	1985
Casco Bay, ME	710.00	710.00
Merrimack River, MA	670.06	670.06
Salem Harbor, MA	57000.00	57000.00
Boston Harbor, MA	79000.00	79000.00
Buzzards' Bay, MA	413.00	413.00
Narragansett Bay, RI	220.00	220.00
East Long Island Sound, NY	290.00	290.00
West Long Island Sound, NY	2090.00	2090.00
Raritan Bay, NJ	24373.52	24374.00
Delaware Bay, DE	91.00	91.00
Lower Chesapeake Bay, VA	4.00	4.00
Pamlico Sound, NC	120.00	120.00
Charleston Harbor, SC	1600.00	1600.00
Sapelo Sound, GA	270.00	270.00
St. Johns River, FL	1400.00	1400.00
Charlotte Harbor, FL	33.00	33.00
Tampa Bay, FL	3.00	3.00
Apalachicola Bay, FL	74.00	74.00
Mobile Bay, AL	100.43	100.00
Round Island, MS	75.00	75.00
Mississippi River Delta, LA	1200.00	1200.00
Barataria Bay, LA	45.00	45.00
Galveston Bay, TX	34.00	34.00
San Antonio Bay, TX	6.00	6.00
Corpus Christi Bay, TX	1.00	1.00
Lower Laguna Madre, TX	27.00	27.00
San Diego Harbor, CA	2600.00	2600.00
San Diego Bay, CA	121.79	122.00
Dana Point, CA	103.27	103.00
Seal Beach, CA	832.72	833.00
San Pedro Canyon, CA	6596.78	6597.00
Santa Monica Bay, CA	471.53	472.00
San Francisco Bay, CA	5093.47	NA
Bodega Bay, CA	29.00	29.00
Coos Bay, OR	30.96	31.00
Columbia River Mouth, OR/WA	261.05	261.00
Nisqually Reach, WA	35.49	35.00
Commencement Bay, WA	5300.00	5300.00
Elliott Bay, WA	7725.95	7726.00
Lutak Inlet, AK	91.78	92.00
Nahku Bay, AK	212.13	212.00

Source: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Ocean Service, Ocean Assessments Division. 1988. National Status and Trends Program for Marine Environmental Quality. A summary of selected data on chemical contaminants in sediments collected during 1984, 1985, 1986, and 1987. Rockville, MD.

Table 2-16c.
Coprostanol in sediments from selected estuaries (nanograms per gram), 1984-1985

Estuary	1984	1985
Casco Bay, ME	221.27	221.00
Merrimack River, MA	206.47	206.00
Salem Harbor, MA	7040.23	7040.00
Boston Harbor, MA	9000.00	9000.00
Buzzards' Bay, MA	1376.60	1377.00
Narragansett Bay, RI	647.80	648.00
East Long Island Sound, NY	17.00	17.00
West Long Island Sound, NY	957.11	957.00
Raritan Bay, NJ	5402.00	5402.00
Delaware Bay, DE	148.00	148.00
Lower Chesapeake Bay, VA	781.56	782.00
Pamlico Sound, NC	1100.00	770.00
Charleston Harbor, SC	1253.23	1838.00
Sapelo Sound, GA	510.00	487.00
St. Johns River, FL	790.07	727.00
Charlotte Harbor, FL	692.47	549.00
Tampa Bay, FL	350.92	602.00
Apalachicola Bay, FL	687.56	651.00
Mobile Bay, AL	304.90	769.00
Round Island, MS	256.87	405.00
Mississippi River Delta, LA	523.98	405.00
Barataria Bay, LA	395.68	374.00
Galveston Bay, TX	278.57	257.00
San Antonio Bay, TX	109.78	124.00
Corpus Christi Bay, TX	248.84	471.00
Lower Laguna Madre, TX	240.00	158.00
San Diego Harbor, CA	600.00	1289.00
San Diego Bay, CA	33.00	239.00
Dana Point, CA	98.00	243.00
Seal Beach, CA	180.00	180.00
San Pedro Canyon, CA	780.00	912.00
Santa Monica Bay, CA	230.00	182.00
San Francisco Bay, CA	1860.00	NA
Bodega Bay, CA	120.00	83.00
Coos Bay, OR	230.00	533.00
Columbia River Mouth, OR/WA	580.00	352.00
Nisqually Reach, WA	5.33	15.00
Commencement Bay, WA	1900.00	2154.00
Elliott Bay, WA	370.00	504.00
Lutak Inlet, AK	83.33	83.00
Nahku Bay, AK	310.00	310.00

Source: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Ocean Service, Ocean Assessments Division. 1988. National Status and Trends Program for Marine Environmental Quality. A summary of selected data on chemical contaminants in sediments collected during 1984, 1985, 1986, and 1987. Rockville, MD.

Table 2-16d.
Chromium and copper in sediments from selected estuaries (parts per million), 1984-1985

Estuary	Chromium		Copper	
	1984	1985	1984	1985
Casco Bay, ME	92.10	92.57	16.97	20.67
Merrimack River, MA	41.15	14.82	6.47	4.73
Salem Harbor, MA	2296.67	2114.67	95.07	82.25
Boston Harbor, MA	223.67	263.29	148.00	157.14
Buzzards' Bay, MA	73.66	85.51	25.02	25.80
Narragansett Bay, RI	93.60	101.64	78.95	79.15
East Long Island Sound, NY	37.63	38.10	11.26	8.58
West Long Island Sound, NY	131.50	134.20	111.00	109.20
Raritan Bay, NJ	181.00	188.88	181.00	178.00
Delaware Bay, DE	27.76	39.68	8.34	9.64
Lower Chesapeake Bay, VA	58.50	59.03	11.32	12.41
Charleston, S.C.	86.33	81.14	16.03	18.46
Pamlico Sound, NC	79.67	55.17	14.13	10.84
Sapelo Sound, GA	51.80	46.58	5.93	6.09
St. Johns River, FL	37.67	29.88	9.77	8.56
Charlotte Harbor, FL	26.47	22.46	1.17	1.12
Tampa Bay, FL	23.70	18.77	4.97	4.35
Apalachicola Bay, FL	69.17	72.27	16.93	17.98
Mobile Bay, AL	93.00	91.68	17.40	17.89
Round Island, MS	NA	48.42	NA	8.06
Mississippi River Delta, LA	72.27	55.42	19.40	16.81
Barataria Bay, LA	52.07	40.16	10.50	8.73
Galveston Bay, TX	41.13	31.63	8.03	7.33
San Antonio Bay, TX	39.43	34.20	5.57	6.14
Corpus Christi Bay, TX	31.43	41.33	6.63	9.75
Lower Laguna Madre, TX	24.53	20.41	5.83	5.65
San Diego Harbor, CA	178.00	129.77	218.67	207.33
San Diego Bay, CA	49.70	43.30	7.67	8.18
Dana Point, CA	39.80	39.77	10.03	8.86
Seal Beach, CA	108.33	108.33	26.00	26.00
San Pedro Canyon, CA	106.50	106.50	31.33	31.33
Santa Monica Bay, CA	53.53	60.23	10.53	10.05
San Francisco Bay, CA	1466.67	NA	160.71	NA
Bodega Bay, CA	246.33	349.67	0.06	3.82
Coos Bay, OR	110.30	81.00	1.47	5.86
Columbia River Mouth, OR/WA	29.53	38.97	17.00	15.80
Nisqually Reach, WA	118.07	114.90	13.33	14.62
Commencement Bay, WA	69.50	64.50	51.33	52.25
Elliott Bay, WA	114.37	91.80	96.00	93.03
Lutak Inlet, AK	58.27	58.27	26.67	26.67
Nahku Bay, AK	23.27	23.27	9.80	9.80

Source: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Ocean Service, Ocean Assessments Division. 1988. National Status and Trends Program for Marine Environmental Quality. A summary of selected data on chemical contaminants in sediments collected during 1984, 1985, 1986, and 1987. Rockville, MD.

Table 2-16e.
Lead and zinc in sediments from selected estuaries (parts per million), 1984-1985

Estuary	Lead		Zinc	
	1984	1985	1984	1985
Casco Bay, ME	29.13	31.65	76.27	93.13
Merrimack River, MA	23.25	21.10	35.75	27.08
Salem Harbor, MA	186.33	167.15	238.00	218.50
Boston Harbor, MA	123.97	126.99	291.67	265.86
Buzzards' Bay, MA	30.72	32.30	97.72	98.18
Narragansett Bay, RI	60.25	60.00	144.43	143.44
East Long Island Sound, NY	22.13	21.18	58.83	53.40
West Long Island Sound, NY	69.75	71.06	243.00	234.20
Raritan Bay, NJ	181.00	182.25	433.75	421.50
Delaware Bay, DE	15.04	17.62	49.66	67.85
Lower Chesapeake Bay, VA	15.70	14.75	66.23	66.15
Pamlico Sound, NC	30.67	24.82	102.67	79.93
Charleston, S.C.	27.33	28.02	72.67	79.74
Sapelo Sound, GA	16.00	15.46	38.33	43.63
St. Johns River, FL	26.00	23.46	67.67	61.11
Charlotte Harbor, FL	4.33	3.84	7.20	7.07
Tampa Bay, FL	4.67	5.70	9.10	12.29
Apalachicola Bay, FL	30.67	30.60	111.67	102.49
Mobile Bay, AL	29.67	30.37	161.00	159.23
Round Island, MS	NA	17.42	NA	63.51
Mississippi River Delta, LA	22.67	20.53	90.00	82.76
Barataria Bay, LA	18.33	15.23	59.33	54.07
Galveston Bay, TX	18.33	14.60	33.97	35.52
San Antonio Bay, TX	11.33	11.53	32.00	35.76
Corpus Christi Bay, TX	13.00	18.21	56.00	97.78
Lower Laguna Madre, TX	11.33	11.30	36.00	32.17
San Diego Harbor, CA	50.97	86.93	327.67	324.17
San Diego Bay, CA	11.61	11.35	58.67	54.72
Dana Point, CA	18.80	14.98	53.67	48.40
Seal Beach, CA	27.37	27.37	125.00	125.00
San Pedro Canyon, CA	17.33	17.33	118.33	118.33
Santa Monica Bay, CA	33.37	25.73	46.67	35.48
San Francisco Bay, CA	67.39	NA	501.66	NA
Bodega Bay, CA	2.17	0.98	38.33	41.33
Coos Bay, OR	4.65	4.60	32.00	45.52
Columbia River Mouth, OR/WA	15.90	9.17	107.67	93.08
Nisqually Reach, WA	24.57	12.18	105.33	100.15
Commencement Bay, WA	34.63	25.48	101.00	94.45
Elliott Bay, WA	20.23	30.05	166.00	176.83
Lutak Inlet, AK	15.90	15.90	180.33	180.33
Nahku Bay, AK	43.30	43.30	191.33	191.33

Source: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Ocean Service, Ocean Assessments Division. 1988. National Status and Trends Program for Marine Environmental Quality. A summary of selected data on chemical contaminants in sediments collected during 1984, 1985, 1986, and 1987. Rockville, MD.

Table 2-16f.
Cadmium and silver in sediments from selected estuaries (parts per million), 1984-1985

Estuary	Cadmium		Silver	
	1984	1985	1984	1985
Casco Bay, ME	0.15	0.24	0.09	0.15
Merrimack River, MA	0.07	0.02	0.05	0.02
Salem Harbor, MA	5.87	6.10	0.88	1.79
Boston Harbor, MA	1.61	1.99	2.64	7.18
Buzzards' Bay, MA	0.23	0.23	0.37	0.80
Narragansett Bay, RI	0.35	0.40	0.56	1.22
East Long Island Sound, NY	0.11	0.10	0.15	0.09
West Long Island Sound, NY	0.73	0.80	0.68	1.64
Raritan Bay, NJ	2.74	2.82	2.06	4.68
Delaware Bay, DE	0.24	0.25	0.11	0.11
Lower Chesapeake Bay, VA	0.38	0.28	0.08	0.08
Pamlico Sound, NC	0.33	0.23	0.09	0.04
Sapelo Sound, GA	0.09	0.17	0.02	0.01
St. Johns River, FL	0.18	0.09	0.11	0.10
Charlotte Harbor, FL	0.08	0.18	0.01	0.01
Tampa Bay, FL	0.15	0.07	0.08	0.06
Apalachicola Bay, FL	0.05	0.17	0.06	0.06
Mobile Bay, AL	0.11	0.10	0.11	0.10
Round Island, MS	NA	0.09	NA	0.05
Mississippi River Delta, LA	0.47	0.41	0.17	0.16
Barataria Bay, LA	0.19	0.15	0.09	0.06
Galveston Bay, TX	0.05	0.04	0.09	0.06
San Antonio Bay, TX	0.07	0.08	0.09	0.06
Corpus Christi Bay, TX	0.19	0.28	0.07	0.05
Lower Laguna Madre, TX	0.09	0.06	0.07	0.05
San Diego Harbor, CA	0.99	1.09	0.76	0.83
San Diego Bay, CA	0.04	0.37	0.75	0.42
Dana Point, CA	0.22	0.44	0.80	0.48
Seal Beach, CA	0.17	0.17	1.27	1.27
San Pedro Canyon, CA	1.17	1.17	1.20	1.20
Santa Monica Bay, CA	0.18	0.29	0.51	0.41
San Francisco Bay, CA	0.51	NA	0.37	NA
Bodega Bay, CA	0.18	0.23	1.74	0.92
Coos Bay, OR	0.62	0.60	0.31	0.19
Columbia River Mouth, OR/WA	0.86	0.78	2.14	1.07
Nisqually Reach, WA	0.68	0.66	2.62	1.37
Commencement Bay, WA	0.77	0.84	5.90	3.02
Elliott Bay, WA	0.84	1.05	1.18	0.67
Lutak Inlet, AK	0.96	0.96	0.09	0.07
Nahku Bay, AK	1.09	1.09	4.37	4.37

Source: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Ocean Service, Ocean Assessments Division. 1988. National Status and Trends Program for Marine Environmental Quality. A summary of selected data on chemical contaminants in sediments collected during 1984, 1985, 1986, and 1987. Rockville, MD.

Table 3-1f.
Mean monthly temperature (degrees Fahrenheit) and precipitation (inches of rainfall) for a city in the humid subtropical climatic zone (Little Rock, Arkansas), 1880-1987

	Temperature			Precipitation
Month	Mean	Highest mean	Lowest mean	Mean
January	41.2	49.9	32.5	4.51
February	44.6	53.8	35.4	3.87
March	53.0	62.8	43.2	4.64
April	62.4	72.4	52.4	5.15
May	70.2	80.0	60.4	5.05
June	78.2	87.9	68.5	3.70
July	81.5	91.1	71.9	3.32
August	80.6	90.4	70.8	3.33
September	74.2	84.4	64.0	3.39
October	63.7	74.4	52.9	3.05
November	51.8	61.6	42.1	4.34
December	43.7	52.3	35.1	4.31

Source: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Climatic Data Center. 1987. Local climatological data: Annual summary with comparative data, Little Rock, Arkansas, pp. 4 A & B. Asheville, NC.

Table 3-1g.
Mean monthly temperature (degrees Fahrenheit) and precipitation (inches of rainfall) for a city in the maritime climatic zone (Seattle, Washington), 1945-1987

	Temperature			Precipitation
Month	Mean	Highest mean	Lowest mean	Mean
January	39.0	44.0	34.0	5.56
February	42.7	48.7	36.6	4.40
March	44.7	51.7	37.6	3.68
April	48.7	56.9	40.5	2.34
May	55.1	64.2	46.0	1.63
June	60.2	69.3	51.0	1.47
July	64.5	74.9	54.1	0.78
August	64.3	74.3	54.3	1.11
September	59.7	68.6	50.8	2.07
October	52.1	59.2	44.9	3.62
November	44.6	50.2	39.0	5.70
December	40.5	45.3	35.7	6.08

Source: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Climatic Data Center. 1987. Local climatological data: Annual summary with comparative data, Seattle, Washington, pp. 4 A & B. Asheville, NC.

Table 3-1h.
Mean monthly temperature (degrees Fahrenheit) and precipitation (inches of rainfall) for a city in the maritime climatic zone (Knoxville, Tennessee), 1871-1987

Month	Temperature			Precipitation
	Mean	Highest mean	Lowest mean	Mean
January	38.9	47.4	30.3	4.55
February	41.7	51.0	32.4	4.52
March	49.4	59.7	39.1	5.10
April	58.8	69.7	47.8	4.11
May	67.3	78.1	56.4	3.83
June	74.8	85.1	64.5	4.03
July	77.8	87.6	67.9	4.51
August	76.8	86.6	66.9	3.63
September	71.4	81.8	60.9	2.81
October	59.8	71.0	48.6	2.67
November	48.4	58.4	38.4	3.40
December	40.7	49.2	32.1	4.36

Source: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Climatic Data Center. 1987. Local climatological data: Annual summary with comparative data, Knoxville, Tennessee, pp. 4 A & B. Asheville, NC.

Table 3-1i.
Mean monthly temperature (degrees Fahrenheit) and precipitation (inches of rainfall) for a city in the humid warm continental climatic zone (Kansas City, Missouri), 1889-1987

Month	Temperature			Precipitation
	Mean	Highest mean	Lowest mean	Mean
January	29.0	37.5	20.4	1.30
February	32.8	41.8	23.9	1.44
March	43.2	52.9	33.5	2.60
April	55.4	65.2	45.6	3.35
May	65.1	74.6	55.6	4.80
June	74.5	83.8	65.1	4.79
July	79.5	89.0	69.9	3.87
August	77.8	87.4	68.1	3.96
September	69.8	79.7	60.0	4.31
October	58.6	68.7	48.6	3.04
November	44.4	53.3	35.5	1.89
December	33.2	41.2	25.2	1.50

Source: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Climatic Data Center. 1987. Local climatological data: Annual summary with comparative data, Kansas City, Missouri, pp. 4 A & B. Asheville, NC.

Table 3-1j.
Mean monthly temperature (degrees Fahrenheit), 1893-1987, and precipitation (inches of rainfall), 1884-1987, for a city in the humid cool continental climatic zone (Burlington, Vermont)

	Temperature			Precipitation
Month	Mean	Highest mean	Lowest mean	Mean
January	17.7	26.2	9.1	1.83
February	18.5	27.3	9.7	1.67
March	29.6	37.9	21.3	2.17
April	42.8	52.1	33.6	2.52
May	55.4	65.6	45.2	3.04
June	64.8	74.8	54.8	3.50
July	69.8	79.8	59.7	3.62
August	67.3	77.1	57.6	3.49
September	59.5	68.9	50.1	3.37
October	48.6	57.2	39.9	2.92
November	36.7	43.4	29.9	2.77
December	23.4	30.7	16.1	2.10

Source: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Climatic Data Center. 1987. Local climatological data: Annual summary with comparative data, Burlington, Vermont, pp. 4 A & B. Asheville, NC.

Table 3-1k.
Mean monthly temperature (degrees Fahrenheit) and precipitation (inches of rainfall) for a city in the steppe climatic zone (Billings, Montana), 1935-1987

	Temperature			Precipitation
Month	Mean	Highest mean	Lowest mean	Mean
January	22.5	31.9	13.2	0.74
February	27.7	37.5	17.9	0.64
March	34.4	44.7	24.1	1.07
April	45.6	57.2	33.9	1.52
May	55.4	67.3	43.4	2.29
June	63.8	76.1	51.4	2.37
July	72.7	86.9	58.4	0.97
August	70.8	84.9	56.6	0.93
September	59.7	72.5	46.8	1.31
October	49.5	61.2	37.8	1.10
November	35.2	44.6	25.7	0.77
December	27.5	36.4	18.5	0.69

Source: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Climatic Data Center. 1987. Local climatological data: Annual summary with comparative data, Billings, Montana, pp. 4 A & B. Asheville, NC.

Table 3-1l.
Mean monthly temperature (degrees Fahrenheit) and precipitation (inches of rainfall) for a city in the undifferentiated highlands climatic zone (Aspen, Colorado), 1951-1980

	Temperature			Precipitation
Month	Mean	Highest mean	Lowest mean	Mean
January	20.6	27.1	15.2	1.96
February	23.5	30.7	15.5	1.61
March	29.0	36.0	22.1	1.90
April	38.4	46.9	31.3	1.69
May	48.1	52.3	44.1	1.52
June	56.5	61.8	51.5	1.21
July	62.5	65.1	60.1	1.46
August	60.5	64.5	57.0	1.85
September	53.4	57.3	47.8	1.56
October	44.0	49.5	37.0	1.54
November	30.7	35.6	24.0	1.55
December	21.8	30.3	16.5	1.82

Source: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Climatic Data Center. 1980. Local climatological data: Annual summary with comparative data, Aspen, Colorado. Asheville, NC.

Table 3-1m.
Mean monthly temperature (degrees Fahrenheit) and precipitation (inches of rainfall) for a city in the subarctic climatic zone (Anchorage, Alaska), 1943-1987

	Temperature			Precipitation
Month	Mean	Highest mean	Lowest mean	Mean
January	13.8	21.0	6.6	0.83
February	17.9	25.8	10.0	0.79
March	24.3	32.7	15.8	0.64
April	35.0	42.8	27.1	0.57
May	46.2	54.5	37.8	0.61
June	54.2	62.0	46.3	1.11
July	58.0	65.3	50.6	1.93
August	55.8	63.1	48.4	2.33
September	47.8	55.1	40.6	2.55
October	34.8	41.1	28.5	1.74
November	21.6	28.0	15.3	1.03
December	14.8	21.3	8.2	1.04

Source: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Climatic Data Center. 1987. Local climatological data: Annual summary with comparative data, Anchorage, Alaska, pp. 4 A & B. Asheville, NC.

Table 3-1n.
Mean monthly temperature (degrees Fahrenheit) and precipitation (inches of rainfall) for a city in the tundra climatic zone (Barrow, Alaska), 1921-1987

	Temperature			Precipitation
Month	Mean	Highest mean	Lowest mean	Mean
January	-14.4	-8.1	-20.8	0.18
February	-18.5	-12.4	-24.6	0.16
March	-15.2	-8.7	-21.7	0.13
April	-1.3	5.9	-8.5	0.15
May	18.9	24.1	13.6	0.13
June	33.8	38.3	29.2	0.32
July	39.3	45.3	33.3	0.86
August	38.1	42.9	33.2	0.90
September	30.4	34.0	26.8	0.59
October	15.4	20.1	10.6	0.51
November	-0.5	5.2	-6.1	0.27
December	-11.2	-5.2	-17.2	0.18

Source: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Climatic Data Center. 1987. Local climatological data: Annual summary with comparative data, Barrow, Alaska, pp. 4 A & B. Asheville, NC.

Table 3-2.
Mean monthly temperature (degree Fahrenheit) inside and outside of urban hotspots

	Washington, D.C.		New York, NY	
Month	Inside	Outside	Inside	Outside
January	35.3	30.1	31.9	31.3
February	37.8	33.2	32.9	33.4
March	46.2	43.1	41.0	40.7
April	56.5	52.8	51.5	50.6
May	66.2	62.3	62.1	60.3
June	74.6	70.8	71.0	69.7
July	78.8	75.5	76.3	75.5
August	77.3	74.1	74.8	74.6
September	70.8	67.1	68.1	67.6
October	59.6	55.0	57.7	57.1
November	48.9	45.5	46.8	47.0
December	38.9	36.0	35.9	36.8

Source: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Climatic Data Center. 1987. Local climatological data: Annual summary with comparative data, Washington, D.C. National Airport, p. 4 B. Asheville, NC.

U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Climatic Data Center. 1987. Local climatological data: Annual summary with comparative data, Washington, D.C. Dulles International Airport, p. 4 B. Asheville, NC.

U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Climatic Data Center. 1987. Local climatological data: Annual summary with comparative data, New York, Central Park, New York, p. 4 B. Asheville, NC.

U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Climatic Data Center. 1987. Local climatological data: Annual summary with comparative data, New York, J.F.K. International Airport, New York, p. 4 B. Asheville, NC.

Note: Data for inside Washington, D.C. are record means (1872-1987) for Washington, D.C. National Airport. Data for outside Washington, D.C. are record means (1963-1987) for Dulles International Airport. Data for inside New York City are record means (1919-1987) for Central Park. Data for outside New York City are record means (1951-1987) for J.F.K. International Airport.

Table 3-3b.
Global carbon dioxide emissions from anthropogenic sources (million metric tons of carbon), 1950-1985

Year	Fossil fuel combustion and industrial processes
1950	1639
1951	1776
1952	1803
1953	1848
1954	1872
1955	2050
1956	2185
1957	2278
1958	2339
1959	2470
1960	2586
1961	2602
1962	2709
1963	2855
1964	3016
1965	3154
1966	3313
1967	3420
1968	3595
1969	3808
1970	4116
1971	4287
1972	4435
1973	4678
1974	4684
1975	4660
1976	4924
1977	5065
1978	5108
1979	5345
1980	5255
1981	5115
1982	5079
1983	5054
1984	5252
1985	5400p

Source: Roty, R.M. 1986, unpublished data. University of New Orleans. New Orleans, LA.

Table 3-3c.
Annual emissions of chlorofluorocarbons (thousand metric tons), 1931-1985

Year	CFC-11	CFC-12
1931	0.0	0.1
1932	0.0	0.1
1933	0.0	0.1
1934	0.0	0.2
1935	0.0	0.3
1936	0.0	0.5
1937	0.0	0.8
1938	0.1	1.2
1939	0.1	1.7
1940	0.1	2.3
1941	0.1	3.0
1942	0.1	3.7
1943	0.2	4.5
1944	0.2	6.1
1945	0.3	8.0
1946	0.6	13.9
1947	1.3	21.3
1948	2.3	24.8
1949	3.8	26.6
1950	5.5	29.5
1951	7.6	32.4
1952	11.0	33.7
1953	15.0	37.9
1954	18.6	42.9
1955	23.0	48.2
1956	28.7	56.1
1957	32.2	63.8
1958	30.2	66.9
1959	30.9	74.8
1960	40.5	89.1
1961	52.1	99.7
1962	65.4	114.5
1963	80.0	133.9
1964	95.0	155.5
1965	108.3	175.4
1966	121.3	195.0
1967	137.6	219.9
1968	156.8	246.5
1969	181.9	274.3
1970	206.6	299.9
1971	226.9	321.8
1972	255.8	349.9
1973	292.4	387.3
1974	321.4	418.6
1975	310.9	404.1
1976	316.7	390.4
1977	303.9	371.2
1978	283.6	341.3
1979	263.7	337.5
1980	250.8	332.5
1981	248.2	340.7
1982	239.5	337.4
1983	252.8	343.3
1984	271.1	359.4
1985	280.8	368.4

Source: Chemical Manufacturers Association. 1986. Production, sales, and calculated release of CFC-11 and CFC-12 through 1985. Washington, D.C.

Table 1-7.
Copper production (million metric tons), 1900-1987

Year	Domestic mine production	Year	Domestic mine production	Year	Domestic mine production
1900	0.27	1930	0.64	1960	0.98
1901	0.27	1931	0.48	1961	1.06
1902	0.30	1932	0.22	1962	1.11
1903	0.32	1933	0.17	1963	1.10
1904	0.37	1934	0.22	1964	1.13
1905	0.40	1935	0.35	1965	1.23
1906	0.42	1936	0.56	1966	1.30
1907	0.38	1937	0.76	1967	0.87
1908	0.43	1938	0.51	1968	1.09
1909	0.51	1939	0.66	1969	1.40
1910	0.49	1940	0.80	1970	1.56
1911	0.51	1941	0.87	1971	1.38
1912	0.57	1942	0.98	1972	1.51
1913	0.56	1943	0.99	1973	1.56
1914	0.52	1944	0.88	1974	1.45
1915	0.67	1945	0.70	1975	1.28
1916	0.91	1946	0.55	1976	1.46
1917	0.86	1947	0.77	1977	1.36
1918	0.87	1948	0.76	1978	1.36
1919	0.55	1949	0.68	1979	1.44
1920	0.56	1950	0.82	1980	1.18
1921	0.21	1951	0.84	1981	1.54
1922	0.44	1952	0.84	1982	1.15
1923	0.67	1953	0.84	1983	1.04
1924	0.73	1954	0.76	1984	1.10
1925	0.76	1955	0.91	1985	1.11
1926	0.78	1956	1.00	1986	1.15
1927	0.75	1957	0.99	1987	1.26
1928	0.82	1958	0.89		
1929	0.90	1959	0.75		

Source: U.S. Department of the Interior, Bureau of Mines. 1988. U.S. and world copper mine production-historical series (data compiled by J.L.W. Jolly). Mineral Yearbook, annual issues. Washington, D.C.

Table 1-8.
Bauxite production (million metric tons), 1900-1987

Year	Domestic mine production
1900	0.023
1901	0.019
1902	0.027
1903	0.049
1904	0.049
1905	0.049
1906	0.076
1907	0.100
1908	0.053
1909	0.131
1910	0.151
1911	0.159
1912	0.163
1913	0.214
1914	0.223
1915	0.302
1916	0.432
1917	0.578
1918	0.615
1919	0.383
1920	0.530
1921	0.142
1922	0.315
1923	0.531
1924	0.353
1925	0.322
1926	0.399
1927	0.326
1928	0.381
1929	0.372
1930	0.336
1931	0.199
1932	0.098
1933	0.157
1934	0.172
1935	0.249
1936	0.386
1937	0.432
1938	0.316
1939	0.381
1940	0.446
1941	0.952
1942	2.644
1943	6.333
1944	2.869
1945	0.997
1946	1.122
1947	1.221
1948	1.481
1949	1.167
1950	1.356
1951	1.878
1952	1.694
1953	1.605
1954	2.027
1955	1.817
1956	1.772
1957	1.439
1958	1.332
1959	1.727
1960	2.030
1961	1.248
1962	1.391
1963	1.549
1964	1.627
1965	1.681
1966	1.825
1967	1.681
1968	1.692
1969	1.873
1970	2.115
1971	2.020
1972	1.841
1973	1.909
1974	1.980
1975	1.801
1976	1.989
1977	2.013
1978	1.669
1979	1.821
1980	1.559
1981	1.510
1982	0.732
1983	0.679
1984	0.856
1985	0.674
1986	0.510r
1987	0.576

Source: U.S. Department of the Interior, Bureau of Mines. 1987. Crude bauxite production (dry equivalent) (data compiled by L. Baumgardner). Mineral Yearbook, annual issues. Washington, D.C.

Table 1-9.
Gold production (million troy ounces), 1840-1987

Year	Domestic mine production	Year	Domestic mine production	Year	Domestic mine production	Year	Domestic mine production
1840	0.024	1872	1.742	1904	3.911	1936	3.783
1841	0.030	1873	1.742	1905	4.265	1937	4.117
1842	0.043	1874	1.620	1906	4.703	1938	4.267
1843	0.058	1875	1.619	1907	4.227	1939	4.673
1844	0.055	1876	1.932	1908	4.435	1940	4.870
1845	0.049	1877	2.269	1909	4.798	1941	4.751
1846	0.055	1878	2.477	1910	4.585	1942	3.457
1847	0.043	1879	1.882	1911	4.686	1943	1.364
1848	0.484	1880	1.742	1912	4.466	1944	0.998
1849	1.935	1881	1.679	1913	4.311	1945	0.955
1850	2.419	1882	1.572	1914	4.418	1946	1.575
1851	2.661	1883	1.451	1915	4.754	1947	2.109
1852	2.902	1884	1.490	1916	4.417	1948	2.014
1853	3.144	1885	1.538	1917	3.900	1949	1.992
1854	2.902	1886	1.687	1918	3.213	1950	2.394
1855	2.661	1887	1.603	1919	2.753	1951	1.981
1856	2.661	1888	1.604	1920	2.383	1952	1.893
1857	2.661	1889	1.595	1921	2.345	1953	1.958
1858	2.419	1890	1.589	1922	2.293	1954	1.837
1859	2.419	1891	1.605	1923	2.405	1955	1.800
1860	2.225	1892	1.597	1924	2.444	1956	1.827
1861	2.080	1893	1.739	1925	2.307	1957	1.794
1862	1.896	1894	1.911	1926	2.233	1958	1.739
1863	1.935	1895	2.255	1927	2.107	1959	1.603
1864	2.230	1896	2.568	1928	2.148	1960	1.667
1865	2.575	1897	2.775	1929	2.059	1961	1.548
1866	2.588	1898	3.118	1930	2.139	1962	1.543
1867	2.502	1899	3.437	1931	2.225	1963	1.454
1868	2.322	1900	3.830	1932	2.269	1964	1.456
1869	2.395	1901	3.806	1933	2.292	1965	1.705
1870	2.419	1902	3.870	1934	2.779	1966	1.803
1871	2.104	1903	3.560	1935	3.237	1967	1.584

(continued)

Table 1-9. (continued)

Year	Domestic mine production	Year	Domestic mine production	Year	Domestic mine production	Year	Domestic mine production
1968	1.478	1973	1.176	1978	0.999	1983	1.960
1969	1.733	1974	1.127	1979	0.964	1984	2.060
1970	1.743	1975	1.052	1980	0.970	1985	2.430
1971	1.495	1976	1.048	1981	1.379	1986	3.740r
1972	1.450	1977	1.100	1982	1.470	1987	4.970

Source: Bureau of the Census. 1976. Historical statistics of the United States: Colonial times to 1970, series M 268. Washington, D.C.

U.S. Department of the Interior, Bureau of Mines. 1979. Minerals in the U.S. economy: Ten-year supply profiles for mineral and fuel commodities, p. 34. Washington, D.C.

U.S. Department of the Interior, Bureau of Mines. 1986. Nonferrous metals supply/demand data, 1974-1984, p. 25. Washington, D.C.

U.S. Department of the Interior, Bureau of Mines. 1987. Mineral commodity summaries, p. 62. Washington, D.C.

U.S. Department of the Interior. 1988. Gold and silver, monthly. Mineral industrial surveys, p. 3. Washington, D.C.

Table 1-10.
Silver production (million troy ounces), 1850-1987

Year	Domestic mine production	Year	Domestic mine production	Year	Domestic mine production
1850	0.039	1888	45.793	1926	62.487
1851	0.039	1889	50.094	1927	59.626
1852	0.039	1890	54.516	1928	57.872
1853	0.039	1891	58.330	1929	60.860
1854	0.039	1892	63.500	1930	47.725
1855	0.039	1893	60.000	1931	29.857
1856	0.039	1894	49.500	1932	22.762
1857	0.039	1895	55.727	1933	23.129
1858	0.039	1896	58.835	1934	32.782
1859	0.077	1897	53.860	1935	48.519
1860	0.116	1898	54.438	1936	61.153
1861	1.547	1899	54.764	1937	71.409
1862	3.480	1900	57.647	1938	61.706
1863	6.574	1901	55.214	1939	64.373
1864	8.508	1902	55.500	1940	70.436
1865	8.701	1903	54.300	1941	67.048
1866	7.734	1904	56.000	1942	54.091
1867	10.441	1905	56.272	1943	41.461
1868	9.281	1906	57.362	1944	34.474
1869	9.281	1907	52.500	1945	29.024
1870	12.375	1908	50.876	1946	22.915
1871	17.789	1909	57.313	1947	35.824
1872	22.236	1910	57.597	1948	38.096
1873	27.650	1911	61.108	1949	34.675
1874	28.868	1912	66.034	1950	42.459
1875	24.530	1913	71.187	1951	39.765
1876	29.996	1914	69.623	1952	39.452
1877	30.778	1915	72.354	1953	37.571
1878	35.022	1916	78.858	1954	36.941
1879	31.566	1917	70.662	1955	37.198
1880	30.319	1918	68.059	1956	38.722
1881	33.258	1919	51.899	1957	38.165
1882	36.197	1920	56.537	1958	34.111
1883	35.733	1921	46.171	1959	31.194
1884	37.744	1922	61.208	1960	30.766
1885	39.909	1923	70.356	1961	34.794
1886	39.694	1924	64.071	1962	36.798
1887	41.722	1925	66.710	1963	35.243

(continued)

Table 1-10. (continued)

Year	Domestic mine production	Year	Domestic mine production	Year	Domestic mine production
1964	36.334	1972	37.200	1980	32.300
1965	39.806	1973	37.800	1981	40.700
1966	43.669	1974	33.800	1982	40.200
1967	32.345	1975	34.900	1983	43.400
1968	32.729	1976	34.300	1984	44.600
1969	41.906	1977	38.200	1985	39.400
1970	45.006	1978	39.400	1986	34.500r
1971	41.600	1979	37.900	1987	39.800

Source: Bureau of the Census. 1976. Historical statistics of the United States: Colonial times to 1970, series M 269. Washington, D.C.

U.S. Department of the Interior, Bureau of Mines. 1979. Minerals in the U.S. economy: Ten-year supply profiles for mineral and fuel commodities, p. 79. Washington, D.C.

U.S. Department of the Interior, Bureau of Mines. 1986. Nonferrous metals supply/demand data, 1974-1984, p. 47. Washington, D.C.

U.S. Department of the Interior, Bureau of Mines. 1987. Mineral commodity summaries, p. 144. Washington, D.C.

Note: Data for 1987 are from the 1987 Mineral Yearbook (in prep).

Table 1-19. (continued)

Year	Rank				Source	
	Bituminous	Sub-bituminous	Lignite	Anthracite	Under-ground	Surface
1940	417.92	0.00	0.00	46.70	416.42	44.91
1941	466.33	0.00	0.00	51.13	456.18	56.59
1942	528.50	0.00	0.00	54.72	508.58	69.18
1943	535.29	0.00	0.00	55.00	501.78	80.43
1944	561.96	0.00	0.00	57.78	508.33	101.45
1945	523.90	0.00	0.00	49.83	455.78	108.88
1946	484.27	0.00	0.00	54.88	416.35	114.12
1947	571.98	0.00	0.00	51.87	479.07	137.86
1948	543.76	0.00	0.00	51.83	450.95	138.64
1949	397.15	0.00	0.00	38.73	325.48	105.59
1950	468.29	i	i	39.98	381.85	126.42
1951	484.03	i	i	38.70	401.06	121.67
1952	423.42	i	i	36.81	345.72	114.51
1953	414.76	i	i	28.07	333.27	109.56
1954	355.28	i	i	26.38	277.51	104.15
1955	421.42	i	i	23.77	324.67	120.52
1956	454.29	i	i	26.21	345.41	135.09
1957	446.88	i	i	22.98	338.82	131.04
1958	372.27	i	i	19.20	269.91	121.57
1959	373.71	i	i	18.73	265.61	126.82
1960	376.87	i	i	17.07	265.37	128.56
1961	365.50	i	i	15.82	253.55	127.77
1962	382.89	i	i	15.32	261.16	137.05
1963	416.25	i	i	16.57	280.24	152.58
1964	441.71	i	i	15.59	297.22	160.07
1965	464.46	i	i	13.48	306.53	171.42
1966	484.23	i	i	11.74	310.75	185.22
1967	501.23	i	i	11.12	319.62	192.73
1968	494.54	i	i	10.40	314.36	190.57
1969	496.29	7.55	4.55	9.50	316.76	201.12
1970	524.67	14.90	7.29	8.82	308.86	246.82
1971	472.86	20.09	7.89	7.92	251.40	257.36
1972	505.06	24.99	9.97	6.45	276.68	269.78
1973	492.98	30.78	12.95	6.19	272.17	270.73
1974	494.94	38.31	14.04	6.00	252.12	301.18
1975	523.81	46.35	17.97	5.63	266.17	327.58
1976	533.65	58.81	23.11	5.65	267.99	353.23
1977	526.96	74.48	25.61	5.32	241.80	390.57
1978	484.36	87.76	31.16	4.57	220.19	387.64
1979	555.34	110.18	38.59	4.39	291.05	417.44
1980	570.29	133.98	42.77	5.49	306.12	446.42

(continued)

Table 1-19. (continued)

Year	Rank				Source	
	Bituminous	Sub-bituminous	Lignite	Anthracite	Under-ground	Surface
1981	551.44	144.84	45.96	4.92	287.06	460.10
1982	562.49	145.98	47.54	4.16	307.61	452.56
1983	515.73	137.00	52.92	3.71	272.44	436.91
1984	589.09	162.53	57.20	3.77	319.31	493.29
1985	556.92r	174.82r	65.68r	4.26r	318.24r	483.35r
1986	562.55	172.00	69.31	3.90	326.95	480.72
1987	576.88p	180.44p	70.67p	3.81p	338.38p	493.33p

Source: Bureau of the Census. 1976. Historical statistics of the United States: Colonial times to 1970, series M 93, 94, 95, 123, 124, 125. Washington, D.C.

U.S. Department of Energy, Energy Information Administration. 1988. Annual energy review 1987, table 75, p. 173. DOE/EIA-0384(87). Washington, D.C.

Note: i=Included in bituminous coal.

Table 1-20.
Domestic production of petroleum products (million barrels per day), 1940-1987

Year	Crude oil	Natural gas plant liquids
1940	3.707	0.153
1941	3.842	0.222
1942	3.799	0.227
1943	4.125	0.241
1944	4.597	0.274
1945	4.695	0.307
1946	4.751	0.318
1947	5.088	0.362
1948	5.535	0.403
1949	5.046	0.430
1950	5.407	0.499
1951	6.158	0.561
1952	6.274	0.612
1953	6.458	0.654
1954	6.342	0.691
1955	6.807	0.771
1956	7.171	0.802
1957	7.170	0.808
1958	6.710	0.808
1959	7.054	0.879
1960	7.055	0.932
1961	7.183	0.991
1962	7.332	1.021
1963	7.542	1.098
1964	7.635	1.157
1965	7.804	1.210
1966	8.295	1.284
1967	8.810	1.409
1968	9.121	1.508
1969	9.238	1.590
1970	9.637	1.660
1971	9.463	1.693
1972	9.467	1.749
1973	9.208	1.738
1974	8.774	1.688
1975	8.375	1.633
1976	8.154	1.608
1977	8.245	1.618
1978	8.707	1.567
1979	8.552	1.584
1980	8.600	1.577
1981	8.572	1.609
1982	8.649	1.550
1983	8.688	1.559
1984	8.880	1.634
1985	8.970	1.610
1986	8.680	1.550
1987	8.310p	1.600p

Source: Bureau of the Census. 1976. Historical statistics of the United States: Colonial times to 1970, series M 143, 138. Washington, D.C.

U.S. Department of Energy, Energy Information Administration. 1988. Annual energy review 1987, table 46, p. 107. DOE/EIA-0384(87). Washington, D.C.

Table 1-21.
Natural gas production (trillion cubic feet), 1900-1987

Year	Domestic well production
1900	0.128
1901	0.180
1902	0.206
1903	0.239
1904	0.257
1905	0.320
1906	0.389
1907	0.407
1908	0.402
1909	0.481
1910	0.509
1911	0.513
1912	0.562
1913	0.582
1914	0.592
1915	0.629
1916	0.753
1917	0.795
1918	0.721
1919	0.746
1920	0.812
1921	0.674
1922	0.776
1923	1.025
1924	1.162
1925	1.210
1926	1.336
1927	1.471
1928	1.596
1929	1.952
1930	1.979
1931	1.722
1932	1.594
1933	1.597
1934	1.816
1935	1.969
1936	2.225
1937	2.473
1938	2.358
1939	2.538
1940	2.734
1941	2.894
1942	3.146
1943	3.516
1944	3.815
1945	4.042
1946	4.153
1947	4.582
1948	5.148
1949	5.420
1950	6.282
1951	7.457
1952	8.013
1953	8.397
1954	8.743
1955	9.405
1956	10.082
1957	10.680
1958	11.030
1959	12.046
1960	12.771
1961	13.250
1962	13.880
1963	14.750
1964	15.550
1965	16.040
1966	17.207
1967	18.171
1968	19.322
1969	20.698
1970	21.921
1971	22.490
1972	22.530
1973	22.650
1974	21.600
1975	20.110
1976	19.950
1977	20.030
1978	19.970
1979	20.470
1980	20.180
1981	19.960
1982	18.520
1983	16.820
1984	18.230
1985	17.200
1986	16.790
1987	17.160p

Source: Bureau of the Census. 1976. Historical statistics of the United States: Colonial times to 1970, series M 147. Washington, D.C.

U.S. Department of Energy, Energy Information Administration. 1988. Annual energy review 1987, table 67, p. 153. DOE/EIA-0384(87). Washington, D.C.

Note: Production data are marketed production which includes extraction loss and transfers to natural gas plant liquids.

Table 1-22.
Net generation of electricity by hydroelectric powerplants (billion kilowatt hours), 1920-1987

Year	Hydro-electric energy	Year	Hydro-electric energy	Year	Hydro-electric energy
1920	16	1943	74	1966	195
1921	15	1944	74	1967	222
1922	17	1945	80	1968	222
1923	19	1946	78	1969	250
1924	19	1947	78	1970	248
1925	22	1948	82	1971	266
1926	26	1949	90c	1972	273
1927	28	1950	96	1973	272
1928	33	1951	100	1974	301
1929	33	1952	105	1975	300
1930	31c	1953	105	1976	284
1931	29	1954	107	1977	220
1932	33	1955	113	1978	280
1933	33	1956	122	1979	280
1934	33	1957	130	1980	276
1935	38	1958	140	1981	261
1936	39	1959	138	1982	309
1937	44	1960	146	1983	332
1938	44	1961	152	1984	321
1939	44	1962	169	1985	281
1940	47	1963	166	1986	291
1941	51	1964	177	1987	250p
1942	64c	1965	194		

Source: Bureau of the Census. 1976. Historical statistics of the United States: Colonial times to 1970, series M 37. Washington, D.C.

U.S. Department of Energy, Energy Information Administration. 1988. Annual energy review 1987, table 83, p. 193. DOE/EIA-0384(87). Washington, D.C.

Table 1-23.
Production of uranium (million pounds of uranium oxide), 1950-1987

Year	Domestic mine production
1950	0.92
1951	1.54
1952	1.74
1953	2.32
1954	3.40
1955	5.56
1956	11.92
1957	16.96
1958	24.88
1959	32.48
1960	35.28
1961	34.70
1962	34.02
1963	28.44
1964	23.70
1965	20.88
1966	21.18
1967	22.51
1968	24.74
1969	23.22
1970	25.81
1971	24.55
1972	25.80
1973	26.47
1974	23.06
1975	23.20
1976	25.49
1977	29.88
1978	36.97
1979	37.47
1980	43.70
1981	38.47
1982	26.87
1983	21.16
1984	14.88
1985	11.31
1986	13.51
1987	13.01p

Source: U.S. Department of Energy, Energy Information Administration. 1988. Annual energy review 1987, table 94, p. 217. DOE/EIA-0384(87). Washington, D.C.

Table 2-3a. (continued)

Year	Elevation	Year	Elevation	Year	Elevation
1964	4192.76	1972	4198.61	1980	4199.23
1965	4193.81	1973	4199.57	1981	4199.31
1966	4194.46	1974	4200.12	1982	4199.99
1967	4194.12	1975	4200.45	1983	4203.75
1968	4194.81	1976	4201.12	1984	4207.87
1969	4195.98	1977	4199.89	1985	4209.07
1970	4195.79	1978	4199.22	1986	4210.56
1971	4197.14	1979	4198.70	1987	4210.79

Source: Arnow, T. 1985. Rise of Great Salt Lake, Utah, pp. 31-33. IN: U.S. Department of the Interior, Geological Survey. 1985. National water summary 1984, fig. 11, p. 33, Water-Supply Paper 2275 (data compiled and updated by T. Arnow, USGS). Reston, VA.

Note: Data are arithmetic means of readings over a calendar year. Data for 1986-1987 updated by agency.

Table 2-3b.
Water levels in the Great Lakes at master gage (water surface elevation, in feet referenced to International Great Lakes Datum 1955), 1950-1987

Year	Lake Superior	Lake Huron	Lake St. Clair	Lake Erie	Lake Ontario
1950	601.28	577.58	573.30	570.67	245.21
1951	601.50	579.14	574.32	571.30	246.39
1952	601.25	580.30	575.16	571.97	246.78
1953	600.78	579.79	574.59	571.34	245.64
1954	600.55	579.47	574.30	571.18	245.53
1955	600.33	579.10	574.35	571.40	246.06
1956	600.28	578.18	573.33	570.64	245.31
1957	600.24	577.60	573.14	570.38	244.38
1958	600.21	577.01	572.32	569.61	243.72
1959	600.54	576.76	572.40	569.75	243.86
1960	600.59	578.28	573.50	570.54	244.62
1961	600.25	577.97	573.42	570.57	244.30
1962	600.22	577.45	572.78	569.95	244.39
1963	600.20	576.48	572.08	569.35	244.47
1964	600.35	575.66	571.45	568.96	243.26
1965	600.34	576.43	571.98	569.32	243.62
1966	600.54	577.25	572.73	569.95	244.56
1967	600.49	577.69	573.30	570.45	245.10
1968	600.84	578.18	573.74	570.92	244.90
1969	600.90	579.01	574.39	571.54	244.74

(continued)

Table 2-3b. (continued)

Year	Lake Superior	Lake Huron	Lake St. Clair	Lake Erie	Lake Ontario
1970	600.72	578.93	574.02	571.10	244.51
1971	601.16	579.36	574.40	571.27	244.63
1972	601.06	579.66	574.90	571.89	245.34
1973	601.22	580.41	575.65	572.71	246.25
1974	601.28	580.28	575.53	572.52	245.77
1975	601.22	579.90	575.22	572.27	244.92
1976	600.86	579.69	575.08	572.13	245.72
1977	600.46	578.38	574.15	571.24	244.78
1978	600.70	578.64	574.41	571.48	245.30
1979	600.89	579.31	574.69	571.55	245.02
1980	600.71	579.37	574.85	571.97	244.99
1981	600.44	579.02	574.49	571.60	244.86
1982	600.64	578.66	575.49	571.66	244.74
1983	601.14	579.44	574.94	571.97	244.96
1984	601.04	579.66	574.97	571.95	245.22
1985	601.47	580.41	575.82	572.61	245.14
1986	601.69	580.97	576.32	573.19	246.04
1987	600.82	579.92	575.35	572.44	245.51

Source: Hitt, K.J. & J.B. Miller. 1986. Great Lakes set record high water levels, pp. 35-40. IN: Department of the Interior, Geological Survey. National water summary, 1985, fig. 15, p. 39, Water-Supply Paper 2300 (data compiled by K.J. Hitt, USGS from data collected by the U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Ocean Survey). Reston, VA.

Note: Data for 1986-1987 updated by agency.

Table 2-4b.
Dams owned and operated by the U.S. Army Corps of Engineers, dams owned and operated by others with federally owned flood control storage controlled by the Corps of Engineers, and dams constructed by the Corps and turned over to others for operation and maintenance (number, cumulative), 1836-1987

Year	Number of dams	Year	Number of dams	Year	Number of dams
1836	1	1933	56	1961	344
1839	3	1934	65	1962	363
1844	6	1935	73	1963	385
1884	9	1936	82	1964	403
1886	10	1937	104	1965	427
1891	11	1938	122	1966	437
1895	12	1939	129	1967	451
1897	13	1940	140	1968	475
1900	14	1941	155	1969	493
1905	16	1942	168	1970	510
1906	17	1943	174	1971	525
1907	20	1944	178	1972	536
1910	21	1945	179	1973	555
1911	22	1946	180	1974	571
1912	23	1947	182	1975	583
1913	25	1948	189	1976	596
1915	28	1949	199	1977	604
1916	29	1950	209	1978	611
1917	32	1951	219	1979	623
1919	33	1952	233	1980	635
1923	34	1953	248	1981	642
1926	37	1954	265	1982	656
1927	39	1955	274	1983	668
1928	40	1956	283	1984	673r
1929	43	1957	289	1985	677r
1930	45	1958	298	1986	681r
1931	50	1959	307	1987	682
1932	51	1960	328		

Source: U.S. Department of Defense, Army Corps of Engineers. 1988. The inventory of dams. Washington, D.C.

Note: Includes dams 25 feet in structural height and/or 50 acre-feet capacity or greater.

Table 2-4c.
Reservoir storage volume capacity for U.S. Army Corps of Engineers dams (storage capacity in millions of acre-feet, cumulative), 1920-1987

Year	Number of dams	Storage volume
1920	32	17
1930	42	23
1940	122	62
1950	183	86
1960	274	119
1970	425	166
1980	524	179
1987	557	215

Source: Langbein, W.B. 1982. Dams, reservoirs and withdrawals for water supply-- historical trends. U.S. Department of the Interior, Geological Survey Open File Report 82-256, p. 3. Reston, VA.

U.S. Department of Defense, Army Corps of Engineers. 1987. The inventory of dams. Washington, D.C.

Note: An acre-foot is the volume of water that would cover one acre to a depth of one foot.

Table 2-6a.
Trend in offstream water use by end user (billions of gallons per day), 1900-1985

Year	Public supply	Rural & domestic livestock	Irrigation	Thermo-electric utility	Other industries
1900	3.0	2.0	20.0	5.0	10.0
1910	5.0	2.2	39.0	7.0	14.0
1920	6.0	2.4	56.0	9.0	18.0
1930	8.0	2.9	60.0	18.0	21.0
1940	10.0	3.1	71.0	23.0	29.0
1945	12.0	3.4	80.0	31.5	35.0
1950	14.0	3.6	89.0	40.0	37.0
1955	17.0	3.6	110.0	72.0	39.0
1960	21.0	3.6	110.0	100.0	38.0
1965	24.0	4.0	120.0	130.0	46.0
1970	27.0	4.5	130.0	170.0	47.0
1975	29.0	4.9	140.0	200.0	45.0
1980	34.0	5.6	150.0	210.0	45.0
1985	37.0r	7.8r	140.0r	190.0r	31.0r

Source: U.S. Department of Commerce, Bureau of the Census. 1976. Historical statistics of the United States, series J 92-103. Washington, D.C.

Solley, W.B., C.F. Merk & R.R. Pierce. 1988. Estimated use of water in the United States in 1985. U.S. Department of the Interior, Geological Survey Circular 1004, p. 69. Reston, VA.

Table 2-6b.
Trend in offstream water use by source of withdrawal (billions of gallons per day), 1950-1985

Year	Ground water	Surface water
1950	34.0	150.0
1955	47.6	198.0
1960	50.4	221.0
1965	60.5	253.0
1970	69.0	303.0
1975	83.0	329.0
1980	83.9r	361.0
1985	73.7r	320.0r

Source: Solley, W.B., C.F. Merk & R.R. Pierce. 1988. Estimated use of water in the United States in 1985. U.S. Department of the Interior, Geological Survey Circular Report 1004, p. 69. Reston, VA.

Table 2-6c.
Trend in instream water use for hydroelectric power (trillions of gallons per day), 1950-1985

Year	Volume
1950	1.1
1955	1.5
1960	2.0
1965	2.3
1970	2.8
1975	3.3
1980	3.3
1985	3.1r

Source: Solley, W.B., C.F. Merk & R.R. Pierce. 1988. Estimated use of water in the United States in 1985. U.S. Department of the Interior, Geological Survey Circular Report 1004, p. 69. Reston, VA.

Table 2-7a.
Municipal wastewater treatment facilities by level of treatment (percentage of total number of facilities), 1986

Level of treatment	Percentage
No treatment	1.3
No discharge	11.4
Less than secondary treatment	13.5
Secondary treatment	19.9
More than secondary treatment	53.9

Source: U.S. Environmental Protection Agency, Municipal Pollution Control. 1987. 1986 needs survey to Congress--assessment of needed publicly owned wastewater treatment facilities in the United States. Washington, D.C.

Table 2-7b.
Annual effluent discharges and daily production estimates for pulp and paper mills (thousands of tons), 1973-1984, with projections to 1994

Year	TSS	BOD	Production
1973	680r	700r	50.1r
1984	190r	200r	57.3r
1994	220r	230r	67.1r

Source: U.S. Environmental Protection Agency, Economic Studies Branch. 1988. Costs and reductions and production associated with direct dischargers, unpublished data. Washington, D.C.

Note: TSS=total suspended solids, BOD=biochemical oxygen demand. The data show what the Clean Water Act accomplished. Without the Clean Water Act pollution controls, the 1984 water effluents would have been 1,090 thousand tons of TSS and 1,100 thousand tons of BOD (assuming 1973 effluent limitations in pounds per ton as applied to 1984 production).

Table 2-13a.
Contaminant levels in herring gull eggs from Lake Superior colonies (parts per million in whole egg samples, wet weight), 1974-1986

	Granite Island, Black Bay, Western Lake Superior					
Year	Perfat	DDE	Dieldrin	Mirex	HCB	PCB
1974	8.79	19.26	0.61	1.30	0.22	75.43
1975	8.16	24.16	0.44	0.62	0.12	82.02
1976	NA	NA	NA	NA	NA	NA
1977	9.23	11.83	0.35	0.24	0.12	54.91
1978	9.72	9.61	0.39	0.39	0.14	45.35
1979	9.24	6.39	0.64	0.19	0.15	59.05
1980	6.85	3.65	0.33	0.09	0.08	27.48
1981	8.44	5.23	0.38	0.09	0.09	31.33
1982	8.45	6.75	0.44	0.22	0.07	39.70
1983	NA	NA	NA	NA	NA	NA
1984	9.74	3.40	0.37	0.05	0.05	17.81
1985	9.40	3.30	0.28	0.09	0.06	19.51
1986	7.40	3.30	0.37	0.09	0.05	14.30

	Agawa Rock, Eastern Lake Superior					
Year	Perfat	DDE	Dieldrin	Mirex	HCB	PCB
1974	8.68	14.19	0.42	0.76	0.29	50.07
1975	7.24	22.03	0.32	1.29	0.24	70.45
1976	NA	NA	NA	NA	NA	NA
1977	9.25	12.01	0.40	0.42	0.13	55.53
1978	9.26	9.68	0.40	0.15	0.09	36.85
1979	9.29	7.26	0.56	0.33	0.14	58.43
1980	8.32	3.70	0.35	0.17	0.08	23.68
1981	8.91	6.26	0.49	0.20	0.14	36.35
1982	8.90	5.83	0.34	0.51	0.10	29.78
1983	8.91	3.49	0.33	0.15	0.05	21.42
1984	9.30	2.49	0.34	0.19	0.06	16.01
1985	9.66	2.97	0.36	0.12	0.05	12.26
1986	7.80	3.13	0.32	0.12	0.05	13.90

Source: Environment Canada, Canadian Wildlife Service, Canada Centre for Inland Waters (data compiled by D.V. Weseloh). 1986. Organochlorine contaminant concentrations in herring gull eggs from Great Lakes colonies. Burlington, ON.

Note: Perfat=Percentage of fat in sample; DDE=Metabolite of dichloro-diphenyl-trichloro ethane (DDT); HCB=Hexachlorobenzene; PCB=Polychlorinated biphenyl.

Table 2-13b.
Contaminant levels in herring gull eggs from Lake Michigan colonies (parts per million in whole egg samples, wet weight), 1976-1986

	Big Sister Island, Green Bay					
Year	Perfat	DDE	Dieldrin	Mirex	HCB	PCB
1976	8.90	33.40	0.82	0.36	0.14	120.00
1977	NA	NA	NA	NA	NA	NA
1978	9.12	21.80	0.90	0.26	0.12	89.98
1979	NA	NA	NA	NA	NA	NA
1980	8.31	11.38	0.65	0.07	0.08	56.95
1981	NA	NA	NA	NA	NA	NA
1982	8.94	17.89	0.75	0.07	0.07	66.89
1983	9.03	6.76	0.53	0.04	0.03	27.66
1984	9.02	9.34	0.64	0.13	0.06	34.00
1985	9.89	7.93	0.54	0.18	0.05	36.82
1986	10.00	7.05	0.28	0.05	0.07	27.00

	Gull Island, Northern Lake Michigan					
Year	Perfat	DDE	Dieldrin	Mirex	HCB	PCB
1976	NA	NA	NA	NA	NA	NA
1977	NA	NA	NA	NA	NA	NA
1978	9.73	22.91	0.83	0.16	0.12	91.49
1979	NA	NA	NA	NA	NA	NA
1980	8.47	12.95	0.75	0.14	0.10	58.70
1981	NA	NA	NA	NA	NA	NA
1982	9.21	13.84	0.88	0.11	0.12	63.93
1983	7.90	6.19	0.68	0.06	0.07	32.65
1984	9.47	6.37	0.41	0.06	0.06	28.93
1985	9.63	5.92	0.40	0.04	0.05	26.51
1986	7.90	7.91	0.49	0.09	0.08	27.50

Source: Environment Canada, Canadian Wildlife Service, Canada Centre for Inland Waters (data compiled by D.V. Weseloh). 1986. Organochlorine contaminant concentrations in herring gull eggs from Great Lakes colonies. Burlington, ON.

Note: Perfat=Percentage of fat in sample; DDE=Metabolite of dichloro-diphenyl-trichloro ethane (DDT); HCB=Hexachlorobenzene; PCB=Polychlorinated biphenyl.

Table 2-13c.
Contaminant levels in herring gull eggs from Lake Huron colonies (parts per million in whole egg samples, wet weight), 1974-1986

	Chantry Island, Southern Lake Huron					
Year	Perfat	DDE	Dieldrin	Mirex	HCB	PCB
1974	8.20	21.00	0.47	2.20	0.47	86.00
1975	8.61	11.85	0.31	0.48	0.18	39.33
1976	NA	NA	NA	NA	NA	NA
1977	9.44	13.32	0.57	0.33	0.17	63.66
1978	11.05	6.02	0.22	0.26	0.14	32.13
1979	7.72	2.54	0.28	0.20	0.10	31.08
1980	9.42	2.83	0.23	0.16	0.08	23.41
1981	9.23	4.08	0.25	0.35	0.07	27.70
1982	8.22	5.03	0.29	0.58	0.08	38.06
1983	8.03	2.22	0.20	0.16	0.05	16.86
1984	8.82	2.55	0.19	0.49	0.07	21.54
1985	9.04	2.47	0.29	0.14	0.05	14.25
1986	8.00	2.00	0.24	0.13	0.05	12.30

	Double Island, North Channel, Lake Huron					
Year	Perfat	DDE	Dieldrin	Mirex	HCB	PCB
1974	9.31	13.83	0.53	0.52	0.30	56.34
1975	7.25	16.22	0.41	0.55	0.24	46.01
1976	NA	NA	NA	NA	NA	NA
1977	9.42	19.03	0.51	0.55	0.21	76.90
1978	8.98	7.04	0.22	0.16	0.09	32.62
1979	8.72	2.06	0.32	0.17	0.10	26.24
1980	9.06	2.60	0.24	0.06	0.06	17.41
1981	9.58	3.56	0.23	0.17	0.07	23.08
1982	8.30	3.84	0.26	0.38	0.07	30.51
1983	8.45	3.25	0.25	0.15	0.05	19.69
1984	9.85	2.58	0.25	0.20	0.06	18.36
1985	9.51	3.08	0.32	0.29	0.07	19.56
1986	8.30	2.10	0.17	0.11	0.04	11.70

Source: Environment Canada, Canadian Wildlife Service, Canada Centre for Inland Waters (data compiled by D.V. Weseloh). 1986. Organochlorine contaminant concentrations in herring gull eggs from Great Lakes colonies. Burlington, ON.

Note: Perfat=Percentage of fat in sample; DDE=Metabolite of dichloro-diphenyl-trichloro ethane (DDT); HCB=Hexachlorobenzene; PCB=Polychlorinated biphenyl.

Table 2-13d.
Contaminant levels in herring gull eggs from Lake Erie colonies (parts per million in whole egg samples, wet weight), 1974-1986

	Port Colborne Lighthouse 1, Eastern Lake Erie					
Year	Perfat	DDE	Dieldrin	Mirex	HCB	PCB
1974	8.5	8.7	0.37	0.84	0.21	72.6
1975	8.2	7.9	0.38	0.42	0.16	53.9
1976	NA	NA	NA	NA	NA	NA
1977	9.8	7.6	0.50	0.51	0.19	59.3
1978	9.0	5.6	0.28	0.38	0.09	46.4
1979	8.6	3.4	0.24	0.25	0.10	37.6
1980	7.6	3.4	0.27	0.30	0.08	37.6
1981	9.6	4.7	0.24	0.42	0.08	44.4
1982	10.6	7.5	0.36	0.60	0.08	59.7
1983	8.3	3.1	0.17	0.29	0.06	36.8
1984	9.5	4.4	0.34	0.38	0.06	45.1
1985	9.2	3.6	0.16	0.24	0.05	29.7
1986	7.6	3.2	0.20	0.25	0.05	23.7

	Middle Island, Western Lake Erie					
Year	Perfat	DDE	Dieldrin	Mirex	HCB	PCB
1974	8.5	5.6	0.34	0.44	0.38	72.4
1975	8.4	6.9	0.28	0.22	0.23	70.7
1976	NA	NA	NA	NA	NA	NA
1977	9.0	7.4	0.31	0.39	0.19	78.1
1978	8.8	3.0	0.21	0.02	0.09	42.4
1979	8.1	2.8	0.27	0.10	0.12	59.3
1980	7.1	2.6	0.16	0.09	0.09	54.3
1981	8.6	3.1	0.20	0.07	0.10	68.6
1982	7.9	2.6	0.24	0.08	0.08	58.8
1983	7.8	1.7	0.24	0.04	0.05	37.9
1984	9.1	2.0	0.32	0.05	0.06	47.3
1985	9.0	2.0	0.22	0.05	0.07	47.2
1986	7.7	2.3	0.26	0.03	0.06	43.0

Source: Environment Canada, Canadian Wildlife Service, Canada Centre for Inland Waters (data compiled by D.V. Weseloh). 1986. Organochlorine contaminant concentrations in herring gull eggs from Great Lakes colonies. Burlington, ON.

Note: Perfat=Percentage of fat in sample; DDE=Metabolite of dichloro-diphenyl-trichloro ethane (DDT); HCB=Hexachlorobenzene; PCB=Polychlorinated biphenyl.

Table 2-13e.
Contaminant levels in herring gull eggs from Lake Ontario colonies (parts per million in whole egg samples, wet weight), 1974-1986

	Snake Island, Eastern Lake Ontario					
Year	Perfat	DDE	Dieldrin	Mirex	HCB	PCB
1974	7.21	21.37	0.47	6.59	0.56	140.00
1975	7.81	23.58	0.35	5.97	0.22	179.59
1976	NA	NA	NA	NA	NA	NA
1977	9.64	16.96	0.50	2.91	0.50	120.00
1978	9.70	10.45	0.28	1.74	0.35	70.68
1979	8.55	8.83	0.19	1.96	0.22	62.90
1980	7.88	7.12	0.20	1.58	0.15	53.49
1981	9.51	11.75	0.27	2.80	0.26	85.62
1982	8.35	8.75	0.27	2.48	0.16	61.48
1983	8.06	5.07	0.21	1.50	0.09	46.18
1984	9.12	7.21	0.28	2.02	0.14	53.34
1985	9.19	7.15	0.18	1.68	0.08	34.59
1986	7.48	4.71	0.18	1.21	0.07	29.45

	Muggs Island, Western Lake Ontario					
Year	Perfat	DDE	Dieldrin	Mirex	HCB	PCB
1974	7.79	23.32	0.46	7.44	0.60	170.00
1975	7.69	22.02	0.24	3.42	0.45	110.00
1976	NA	NA	NA	NA	NA	NA
1977	8.79	12.80	0.28	2.05	0.34	86.62
1978	8.64	10.91	0.25	1.39	0.28	74.63
1979	8.73	9.05	0.22	1.81	0.21	76.29
1980	7.86	8.17	0.18	1.72	0.20	59.69
1981	8.93	10.26	0.28	2.53	0.23	72.17
1982	8.66	11.47	0.29	3.69	0.16	64.47
1983	8.49	4.49	0.14	1.36	0.07	39.01
1984	8.89	5.32	0.13	1.72	0.11	48.87
1985	9.14	4.90	0.13	1.26	0.06	36.57
1986	8.10	4.00	0.14	0.98	0.07	25.04

Source: Environment Canada, Canadian Wildlife Service, Canada Centre for Inland Waters (data compiled by D.V. Weseloh). 1986. Organochlorine contaminant concentrations in herring gull eggs from Great Lakes colonies. Burlington, ON.

Note: Perfat=Percentage of fat in sample; DDE=Metabolite of dichloro-diphenyl-trichloro ethane (DDT); HCB=Hexachlorobenzene; PCB=Polychlorinated biphenyl.

Table 2-14a.
Pollutant discharges into coastal waters by region (million tons per year), circa 1980-1985

Coastal region	BOD	TSS	TN	TP
Northeast	0.57	5.33	0.14	0.05
Mid-Atlantic	0.54	5.42	0.20	0.05
Southeast	0.25	3.18	0.14	0.04
Gulf of Mexico	2.03	149.00	0.88	0.22
West Coast	1.52	101.12	0.64	0.76

Source: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Ocean Survey, Ocean Assessments Division, Strategic Assessment Branch. 1986. Pollutant discharges from East Coast and Gulf of Mexico coastal counties, circa 1980-1985 and unpublished data compiled from the National Coastal Pollutant Discharge Inventory database. Rockville, MD.

Note: BOD=biochemical oxygen demand; TSS=total suspended solids; TN= total nitrogen; TP=total phosphorus.

Table 2-14b.
Point sources of pollutants to coastal waters by region (number of wastewater discharge facilities), circa 1980-1985

Coastal region	Municipal wastewater treatment facilities	Industrial wastewater treatment facilities
Northeast	540	1025
Mid-Atlantic	666	1518
Southeast	1053	458
Gulf of Mexico	1651	830
West Coast	521	920

Source: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Ocean Survey, Ocean Assessments Division, Strategic Assessment Branch. 1986. Pollutant discharges from East Coast and Gulf of Mexico coastal counties, circa 1980-1985 and unpublished data compiled from the National Coastal Pollutant Discharge Inventory database. Rockville, MD

Table 2-16g.
Mercury in sediments from selected estuaries (parts per million), 1984-1985

Estuary	1984	1985
Casco Bay, ME	0.12	0.14
Merrimack River, MA	0.08	0.01
Salem Harbor, MA	1.19	1.07
Boston Harbor, MA	1.05	1.03
Buzzards' Bay, MA	0.12	0.12
Narragansett Bay, RI	0.00	0.30
East Long Island Sound, NY	0.09	0.01
West Long Island Sound, NY	0.48	0.45
Raritan Bay, NJ	2.34	2.24
Delaware Bay, DE	0.09	0.06
Lower Chesapeake Bay, VA	0.10	0.05
Pamlico Sound, NC	0.11	0.07
Sapelo Sound, GA	0.03	0.02
St. Johns River, FL	0.07	0.03
Charlotte Harbor, FL	0.02	0.02
Tampa Bay, FL	0.03	0.03
Apalachicola Bay, FL	0.06	0.04
Mobile Bay, AL	0.12	0.01
Round Island, MS	NA	0.02
Mississippi River Delta, LA	0.06	0.04
Barataria Bay, LA	0.05	0.05
Galveston Bay, TX	0.03	0.02
San Antonio Bay, TX	0.02	0.02
Corpus Christi Bay, TX	0.04	0.04
Lower Laguna Madre, TX	0.03	0.02
San Diego Harbor, CA	1.04	1.06
San Diego Bay, CA	0.04	0.02
Dana Point, CA	0.13	0.18
Seal Beach, CA	0.59	0.59
San Pedro Canyon, CA	0.32	0.31
Santa Monica Bay, CA	0.01	ND
San Francisco Bay, CA	0.25	NA
Bodega Bay, CA	0.14	0.14
Coos Bay, OR	0.11	0.06
Columbia River Mouth, OR/WA	0.25	0.14
Nisqually Reach, WA	0.32	0.17
Commencement Bay, WA	0.01	0.06
Elliott Bay, WA	0.11	0.43
Lutak Inlet, AK	0.24	0.24
Nahku Bay, AK	0.23	0.23

Source: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Ocean Service, Ocean Assessments Division. 1988. National Status and Trends Program for Marine Environmental Quality. A summary of selected data on chemical contaminants in sediments collected during 1984, 1985, 1986, and 1987. Rockville, MD.

Table 2-17a.
Oil spills in and around U.S. waters (thousands of spills and millions of gallons), 1970-1985

Year	Number	Volume
1970	3.71	15.25
1971	8.74	8.84
1972	9.93	18.81
1973	13.23	22.11
1974	14.43	19.42
1975	12.78	22.24
1976	13.93	36.61
1977	15.33	11.25
1978	14.50	17.56
1979	13.13	13.66
1980	11.16	15.09
1981	10.56	19.77
1982	10.41r	23.15r
1983	11.35r	30.08r
1984	13.02r	18.16r
1985	10.99p	23.97p

Source: U.S. Department of Transportation, United States Coast Guard. Polluting incidents in and around U.S. waters, annual. COMDTINST M16450A-F (old CG-487). Washington, D.C.

Table 2-17b.
Hazardous waste spills in and around U.S. waters (number of spills and millions of pounds), 1974-1984

Year	Number	Volume
1974	42	1.12
1975	42	3.08
1976	54	13.16
1977	57	0.85
1978	49	0.24
1979	47	1.74
1980	63	0.27
1981	102	0.55
1982	175	8.66
1983	1031	3.41
1984	1433	3.80

Source: U.S. Department of Transportation, United States Coast Guard. Polluting incidents in and around U.S. waters, annual. COMDTINST M16450A-F (old CG-487). Washington, D.C.

Table 2-17c.
Oil spills in and around U.S. waters by region (percentage of total volume spilled), 1977-1984

Year	Inland	Atlantic	Pacific	Gulf	Great Lakes	Other
1977	38.80	17.80	3.70	30.20	9.50	NA
1978	26.20	44.80	1.80	26.10	1.00	NA
1979	37.80	13.20	24.00	22.80	2.20	NA
1980	44.10	37.10	8.40	6.80	3.50	NA
1981	88.10	6.40	2.40	2.40	0.70	NA
1982	79.50	3.90	1.60	13.30	0.20	NA
1983	20.00	4.30	44.20	2.50	0.00	28.90
1984	22.50	40.50	11.50	3.70	7.00	14.80

Source: U.S. Department of Transportation, United States Coast Guard. Polluting incidents in and around U.S. waters, annual. COMDTINST M16450A-F (old CG-487). Washington, D.C.

Table 2-17d.
Oil spills in and around U.S. waters by location (percentage of total volume spilled), 1976-1984

Year	Internal waters	River channels	Ports & harbors	Non-navigable waters/beaches
1976	0.30	31.80	12.70	28.50
1977	1.30	40.90	17.80	31.90
1978	1.00	57.10	6.70	17.30
1979	0.20	44.90	11.40	22.00
1980	3.70	36.50	11.40	26.70
1981	2.80	79.30	5.20	11.10
1982	1.20	42.90	4.50	47.80
1983	6.10	23.30	54.10	13.40
1984	6.50	20.00	42.80	30.00

Year	Territorial sea (0-3mi)	Contiguous zone (3-12mi)	High seas (>12mi)
1976	2.20	0.10	24.30
1977	5.40	0.30	2.30
1978	17.50	0.20	0.20
1979	17.50	3.70	0.40
1980	19.50	0.00	2.10
1981	0.60	0.20	0.80
1982	2.30	0.50	0.50
1983	2.30	0.50	0.50
1984	0.40	0.30	0.00

Source: U.S. Department of Transportation, United States Coast Guard. Polluting incidents in and around U.S. waters, annual. COMDTINST M16450A-F (old CG-487). Washington, D.C.

Table 2-17e.
Oil spills in and around U.S. waters by source (percentage of total volume spilled), 1973-1983

Year	Vessels	Land vehicles	Non-transportation	Transportation pipeline	Marine facilities	Land facilities	Miscellaneous/ unknown
1973	32.70	3.00	21.80	7.60	5.60	0.60	28.80
1974	25.00	5.00	20.90	36.00	45.00	1.00	4.00
1975	44.60	7.10	27.70	17.00	0.90	1.30	1.40
1976	33.10	1.90	48.00	13.40	1.10	1.30	0.70
1977	21.70	6.30	29.60	24.20	5.20	1.90	10.90
1978	25.90	3.60	18.40	9.30	36.20	2.80	3.80
1979	31.10	4.40	26.10	24.20	4.40	2.00	7.80
1980	41.90	2.90	22.40	20.00	7.80	0.90	4.00
1981	73.30	1.90	13.00	6.90	2.80	0.50	1.60
1982	26.50	3.50	26.10	36.70	2.90	0.80	3.40
1983	11.30	1.90	59.60	14.00	1.10	0.30	11.80

Source: U.S. Department of Transportation, United States Coast Guard. Polluting incidents in and around U.S. waters, annual. COMDTINST M16450A-F (old CG-487). Washington, D.C.

Table 3-1b.
Mean monthly temperature (degrees Fahrenheit), 1947-1987, and precipitation (inches of rainfall), 1943-1987, for a city in the tropical rainforest climatic zone (Hilo, Hawaii)

	Temperature			Precipitation
Month	Mean	Highest mean	Lowest mean	Mean
January	71.3	79.3	63.2	9.24
February	71.2	79.2	63.1	11.84
March	71.4	78.9	63.9	13.78
April	72.3	79.4	65.1	13.26
May	73.4	80.7	66.1	9.15
June	74.8	82.4	67.2	6.19
July	75.4	82.7	68.2	9.48
August	75.9	83.2	68.7	9.82
September	75.8	83.4	68.2	7.37
October	75.2	82.7	67.6	9.75
November	73.6	80.8	66.3	14.20
December	71.8	79.2	64.4	13.70

Source: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Climatic Data Center. 1987. Local climatological data: Annual summary with comparative data, Hilo, Hawaii, pp. 4 A & B. Asheville, NC.

Table 3-1c.
Mean monthly temperature (degrees Fahrenheit) and precipitation (inches of rainfall), for a city in the tropical savanna climatic zone (Key West, Florida),1871-1987

	Temperature			Precipitation
Month	Mean	Highest mean	Lowest mean	Mean
January	69.8	74.7	65.0	1.83
February	70.8	75.8	65.8	1.69
March	73.4	78.4	68.4	1.53
April	76.6	81.5	71.6	1.72
May	79.8	84.7	74.9	2.64
June	82.5	87.4	77.5	4.44
July	83.8	89.0	78.7	3.62
August	83.9	89.2	78.6	4.57
September	82.7	87.8	77.6	6.46
October	79.4	83.8	74.9	5.50
November	74.8	79.1	70.4	2.46
December	71.0	75.6	66.4	1.82

Source: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Climatic Data Center. 1987. Local climatological data: Annual summary with comparative data, Key West, Florida, pp. 4 A & B. Asheville, NC.

Table 3-1d.
Mean monthly temperature (degrees Fahrenheit) and precipitation (inches of rainfall) for a city in the desert climatic zone (Phoenix, Arizona), 1896-1987

	Temperature			Precipitation
Month	Mean	Highest mean	Lowest mean	Mean
January	52.1	65.2	39.0	0.76
February	56.0	69.4	42.5	0.75
March	60.8	74.7	46.9	0.73
April	68.3	83.3	53.2	0.33
May	76.6	92.2	60.9	0.13
June	85.7	101.9	69.8	0.10
July	91.3	104.4	78.1	0.94
August	89.4	102.2	76.7	1.01
September	84.0	97.9	70.0	0.80
October	72.2	87.0	57.4	0.51
November	60.3	74.7	45.8	0.63
December	52.9	66.0	39.7	0.91

Source: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Climatic Data Center. 1987. Local climatological data: Annual summary with comparative data, Phoenix, Arizona, pp. 4 A & B. Asheville, NC.

Table 3-1e.
Mean monthly temperature (degrees Fahrenheit), 1888-1987, and precipitation (inches of rainfall), 1878-1987, for a city in the Mediterranean climatic zone (Fresno, California)

	Temperature			Precipitation
Month	Mean	Highest mean	Lowest mean	Mean
January	45.9	54.3	37.5	1.81
February	51.1	61.3	40.9	1.64
March	55.1	66.4	43.7	1.70
April	61.0	74.2	47.7	0.96
May	67.9	82.6	53.3	0.34
June	75.5	91.4	59.6	0.10
July	81.7	98.6	64.8	0.01
August	80.0	96.8	63.2	0.01
September	74.0	89.8	58.2	0.17
October	64.8	79.0	50.6	0.54
November	54.2	65.9	42.4	1.03
December	46.3	54.8	37.8	1.55

Source: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Climatic Data Center. 1987. Local climatological data: Annual summary with comparative data, Frenso, California, pp. 4 A & B. Asheville, NC.

Table 3-3d.
Average annual concentrations of carbon dioxide in the atmosphere (parts per million, volume basis), 1958-1986

Year	Mauna Loa, Hawaii (20°N)		South Pole (90°S)	
	Concentration	Annual Increase	Concentration	Annual Increase
1958	NA	NA	314.6	NA
1959	316.1	NA	315.4	0.9
1960	317.0	0.9	316.7	1.3
1961	317.7	0.7	317.5	0.8
1962	318.6	0.9	618.0	0.5
1963	319.1	0.5	318.2	0.2
1964	319.6	0.5	318.3	0.1
1965	320.4	0.8	319.3	1.0
1966	321.1	0.7	320.6	1.3
1967	321.8	0.7	321.2	0.6
1968	322.8	1.0	321.8	0.6
1969	324.2	1.4	322.6	0.7
1970	325.5	1.3	324.2	1.6
1971	326.5	1.0	325.0	0.8
1972	327.7	1.3	325.8	0.8
1973	329.7	2.0	327.4	1.7
1974	330.4	0.7	328.3	0.9
1975	331.0	0.6	329.3	1.0
1976	332.1	1.1	330.4	1.1
1977	333.6	1.5	331.9	1.4
1978	335.2	1.6	333.5	1.6
1979	336.6	1.4	334.9	1.3
1980	338.4	1.7	336.8	1.9
1981	339.5	1.1	338.1	1.3
1982	340.7	1.3	339.2	1.1
1983	342.7	2.0	341.0	1.8
1984	344.4	1.7	342.4	1.4
1985	345.6	1.2	NA	NA
1986	346.7p	1.1	NA	NA

Source: Keeling, C.D., Scripps Institution of Oceanography, unpublished data.

Table 3-3e.
Atmospheric concentrations of chlorofluorocarbons (parts per trillion) and nitrogen dioxide and methane (parts per billion), 1975-1984

Year	CFC-11	CFC-12	Nitrogen dioxide	Methane
1975	120	200	291.4	1525
1976	133	217	293.3	1555
1977	148	239	294.6	1573
1978	159	266	296.4	1596
1979	167	283	296.3	1619
1980	179	307	297.6	1639
1981	185	315	298.5	1656
1982	193	330	301.0	1671
1983	205	350	300.9	1663
1984	213	366	300.4	1689
1985	223	384	301.5	1711

Source: Rasmussen, R.A. & M.A.K. Khalil. 1986. Atmospheric trace gases: trends and distributions over the last decade. Science, 232: 1623-1624.

Table 3-4.
National ambient concentrations of selected air quality indicators (means, parts per million and micrograms per cubic meter), 1975-1986

Year	Sulfur dioxide (ppm)	Carbon monoxide (ppm)	Ozone (ppm)	Nitrogen dioxide (ppm)	TSP (ug/m3)	Lead (ug/m3)
1975	0.015	11.96	0.153	0.029	61.9	1.04
1976	0.016	11.32	0.153	0.029	62.8	1.05
1977	0.014	10.66	0.155	0.029	62.9	1.16
1978	0.013	10.17	0.156	0.029	62.4	1.04
1979	0.012	9.80	0.142	0.029	63.4	0.79
1980	0.011	9.08	0.145	0.028	64.8	0.55
1981	0.010	8.82	0.131	0.027	60.2	0.44
1982	0.098	8.13	0.128	0.026	50.2	0.47
1983	0.009	8.02	0.145	0.025	49.7	0.39
1984	0.010	8.00	0.130	0.026	50.9	0.35
1985	0.009	7.19	0.127	0.025	48.5	0.23
1986	0.009	7.21	0.123	0.025	48.4	0.15

Source: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. 1988. National air quality and emissions trends report, 1986, trend statistics used in fig. 5-15, pp. 5-31. EPA-450/4-88-001. Research Triangle Park, NC.

Note: TSP=total suspended particulates. Sulfur dioxide and nitrogen dioxide records are arithmetic means. Carbon monoxide records are second maximum reading over a 8 hour period. Oxone records are second maximum reading over a 24 hour period. TSP records are geometric means. Lead records are maximum quarter recordings.

Table 3-5a.
Recent trends in sulfur dioxide emissions by source (million metric tons), 1970-1986

Year	Transportation	Fuel combustion	Industrial processes	Solid waste	Miscellaneous	Total
1970	0.6	21.3	6.4	0.0	0.1	28.3
1975	0.6	20.3	4.7	0.0	0.0	25.6
1976	0.7	20.9	4.6	0.0	0.0	26.2
1977	0.8	21.5r	4.7r	0.0	0.0	26.9r
1978	0.8	19.9r	4.3r	0.0	0.0	25.0r
1979	0.9	19.8r	4.4r	0.0	0.0	25.1r
1980	0.9	19.3r	3.8r	0.0	0.0	23.9r
1981	0.9r	18.8r	3.9r	0.0	0.0	23.5r
1982	0.8	17.8r	3.3r	0.0	0.0	22.0r
1983	0.8	17.4r	3.3r	0.0	0.0	21.5r
1984	0.8r	17.9r	3.3r	0.0	0.0	22.1r
1985	0.9	17.6	3.2	0.0	0.0	21.6
1986	0.9	17.2	3.1	0.0	0.0	21.2

Source: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. 1988. National air quality and emissions trends report, 1986, table 3-2, p. 3-16. EPA-450/4-88-001. Research Triangle Park, NC.

U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, National Air Data Branch. 1988. National air pollutant emission estimates, 1940-1986. table 1, p. 2. EPA-450/4-87-024. Research Triangle Park, N.C.

Table 3-5b.
Historical sulfur dioxide emissions by source (million metric tons), 1900-1980

Year	Electric utilities	Industrial process	Commercial/ residential	Transportation	Other
1900	1.315	4.322	1.267	2.828	1.254
1905	1.917	6.197	1.793	4.068	1.378
1910	2.286	7.830	2.319	5.051	1.516
1915	2.630	9.426	3.027	5.590	1.583
1920	3.039	9.266	3.164	6.157	1.630
1925	3.322	10.997	3.660	5.762	1.847
1930	2.812	9.215	4.006	5.147	2.033
1935	2.072	7.266	3.351	4.047	1.938
1940	3.276	9.524	3.577	4.352	1.841
1945	4.453	9.963	5.548	6.367	2.278
1950	5.609	8.735	3.160	3.067	2.752
1955	7.623	9.308	2.182	1.165	2.694
1960	10.446	8.509	2.306	0.564	2.671
1965	14.084	9.920	2.009	0.506	2.906
1970	19.603	9.747	2.126	0.626	3.038
1975	21.526	6.211	1.477	0.704	2.553
1978	19.080	5.972	1.363	0.914	2.643
1980	19.852	5.554	1.019	1.016	2.476

Source: Gschwandtner, G. K. Gschwandtner, K. Eldridge, C. Mann and D. Mobley. 1986. Historic emissions of sulfur and nitrogen oxides in the United States from 1900 to 1980. Journal of the Air Pollution Control Association, vol. 36, no. 2.

Table 3-5c.
Sulfur dioxide emissions by state (thousands of metric tons), 1900-1987

State	1900	1950	1977	1980	1984	1987
Alabama	112.5	281.6	933.0	728.8r	690.2	765.2
Arizona	148.3	1200.1	1175.0	710.6r	579.4	595.6
Arkansas	87.8	89.1	98.8	73.8r	106.9	112.9
California	154.0	652.3	535.7	427.1r	301.6	307.0
Colorado	80.7	67.1	131.9	126.1r	131.3	122.5
Connecticut	110.2	180.4	42.3	50.1r	70.2	65.5
Delaware	5.2	34.1	141.7	126.0r	117.8	115.3
District of Columbia	NA	NA	22.4	13.3r	12.9	11.3
Florida	63.9	306.9	853.8	887.2r	703.2	749.6
Georgia	95.9	196.9	635.4	769.4r	917.3	877.8
Idaho	46.6	115.5	46.2	39.5r	48.9	48.3
Illinois	1604.9	2932.6	1632.8	1347.8r	1292.0	1130.0
Indiana	495.9	1310.1	1701.1	1745.6r	1748.4	1495.1
Iowa	503.4	575.3	294.5	290.8r	258.0	259.3
Kansas	287.0	210.1	197.0	204.9r	214.5	217.2
Kentucky	228.6	436.7	1383.4	1083.8r	753.3	861.6

(continued)

Table 3-5c (continued)

State	1900	1950	1977	1980	1984	1987
Louisiana	154.6	198.0	500.3	417.0r	331.5	352.5
Maine	60.7	61.6	109.9	94.8r	65.8	67.9
Maryland	122.7	319.0	265.0	261.5r	287.5	281.7
Massachusetts	248.6	306.9	222.8	317.1r	267.7	272.4
Michigan	418.8	1076.9	1112.6	753.7r	769.1	639.2
Minnesota	222.5	238.7	267.2	215.9r	154.6	133.9
Mississippi	89.1	138.6	335.6	258.9r	191.6	216.0
Missouri	493.9	557.7	1294.3	1209.1r	1141.2	964.3
Montana	341.2	330.0	197.6	141.5r	123.4	125.0
Nebraska	211.4	110.0	51.1	68.4r	63.9	61.1
Nevada	7.9	172.7	193.6	130.2r	133.6	129.0
New Hampshire	49.1	31.9	75.6	91.8r	86.4	76.1
New Jersey	301.2	662.2	284.9	248.2r	201.6	196.0
New Mexico	44.7	239.8	342.8	280.0r	286.0	233.8
New York	764.0	1354.1	882.7	769.7r	716.5	626.5
North Carolina	56.9	338.8	558.1	541.6r	433.4	396.4
North Dakota	16.9	71.5	86.2	102.1r	120.7	109.3
Ohio	1080.0	2431.0	2942.5	2429.1r	2388.8	2414.3
Oklahoma	73.7	256.3	63.6	93.3r	147.8	143.4
Oregon	14.3	83.6	44.4	43.6r	36.3	34.2
Pennsylvania	819.2	1930.5	1698.6	1742.6r	1464.3	1507.8
Rhode Island	54.3	80.3	9.7	11.0r	7.3	7.0
South Carolina	35.0	156.2	285.6	290.7r	228.1	243.1
South Dakota	16.7	29.7	37.1	36.4r	39.3	21.0
Tennessee	164.5	412.5	1344.2	986.6r	809.0	900.5
Texas	427.8	869.0	899.8	977.2r	986.5	1133.9
Utah	67.3	657.8	103.8	84.7r	81.9	100.4
Vermont	38.1	13.2	7.7	7.3r	6.7	5.6
Virginia	101.9	426.8	386.8	301.2r	265.1	285.8
Washington	39.8	220.0	352.4	278.5r	232.2	231.6
West Virginia	92.3	408.1	1080.1	1015.4r	966.7	972.4
Wisconsin	281.3	501.6	627.7	593.7r	531.9	416.3
Wyoming	31.1	51.7	177.6	180.1r	197.1	187.1

Source: Gschwandtner, G. K. Gschwandtner, K. Eldridge, C. Mann and D. Mobley. 1986. Historic emissions of sulfur and nitrogen oxides in the United States from 1900 to 1980. Journal of the Air Pollution Control Association, vol. 36, no. 2.

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Kohout, E.J., D.A. Knudson, C.L. Saricks & D.J. Miller. 1987. Estimated monthly emissions of sulfur dioxide, oxides of nitrogen, and volatile organic compounds for the 48 contiguous states, 1985-1986. ANL/EES-TM-335, vol. 1. Argonne National Laboratory, Argonne, IL.

Table 3-6a.
Recent trends in nitrogen oxides emissions by source (million metric tons), 1970-1986

Year	Transportation	Fuel combustion	Industrial processes	Solid waste	Miscellaneous	Total
1970	7.6	9.1	0.7	0.4	0.3	18.1
1975	8.9	9.4	0.7	0.1	0.1	19.2
1976	9.3	10.0	0.7	0.1	0.2	20.3
1977	9.5	10.4r	0.7	0.1	0.2	21.0
1978	9.7	10.3	0.7	0.1	0.2	21.1r
1979	9.5r	10.5	0.7	0.1	0.2	21.0r
1980	9.2	10.1r	0.7	0.1	0.2	20.3r
1981	9.3	10.0r	0.6r	0.1	0.2	20.3r
1982	8.9	9.8r	0.5r	0.1	0.1	19.5r
1983	8.6	9.6	0.5r	0.1	0.2	19.1
1984	8.7	10.2	0.6	0.1	0.2	19.7
1985	8.8	10.2	0.6	0.1	0.1	19.7
1986	8.5	10.0	0.6	0.1	0.1	19.3

Source: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. 1988. National air quality and emissions trends report, 1986, table 3-4, p. 3-29. EPA-450/4-88-001. Research Triangle Park, NC.

Table 3-6b.
Historical nitrogen oxide emissions by source (million metric tons), 1900-1980

Year	Electric utilities	Industrial process	Commercial/ residential	Transportation	Other
1900	0.564	0.759	0.202	0.347	0.996
1905	0.799	1.063	0.231	0.507	1.047
1910	0.913	1.575	0.271	0.649	1.103
1915	1.029	1.896	0.315	0.788	1.113
1920	1.125	2.045	0.323	1.059	1.120
1925	1.124	2.536	0.356	2.786	1.227
1930	0.887	2.596	0.382	3.197	1.755
1935	0.667	2.066	0.339	2.867	1.361
1940	1.056	2.507	0.370	3.188	1.189
1945	1.397	3.105	0.531	4.059	1.409
1950	1.777	3.229	0.469	4.076	1.789
1955	2.346	3.980	0.399	4.506	1.488
1960	2.981	4.822	0.756	5.117	1.295
1965	3.920	5.793	0.782	6.195	1.546
1970	5.694	4.795	0.914	8.193	1.746
1975	6.929	4.191	0.822	9.494	1.114
1978	7.466	4.681	0.845	10.600	1.063
1980	8.752	3.947	0.784	10.071	0.931

Source: Gschwandtner, G. K. Gschwandtner, K. Eldridge, C. Mann and D. Mobley. 1986. Historic emissions of sulfur and nitrogen oxides in the United States from 1900 to 1980. Journal of the Air Pollution Control Association, vol. 36, no. 2.

Table 3-6c.
Nitrogen oxide emissions by state (thousand metric tons), 1900-1987

State	1900	1950	1977	1980	1984	1987
Alabama	101.4	169.4	440.3	423.4r	393.0	433
Arizona	3.0	67.1	218.6	230.8r	233.7	239.9
Arkansas	173.8	140.8	178.5	179.6r	212.2	246.4
California	53.8	863.5	1309.3	1206.7r	1098.5	1193.4
Colorado	28.8	90.2	266.7	263.4r	279.6	291.9
Connecticut	36.0	99.0	135.5	126.7r	117.9	134.2
Delaware	3.0	20.9	60.3	56.9r	64.9	67.5
District of Columbia	NA	NA	27.9	24.3r	22.7	746.3
Florida	58.0	237.6	658.3	654.4r	628.1	24.5
Georgia	79.2	217.8	500.8	533.4r	565.7	587.5
Idaho	7.4	35.2	84.9	83.8r	80.0	86.6
Illinois	226.5	685.3	907.1	879.6r	811.9	822.0
Indiana	80.7	336.6	688.3	683.3r	710.2	714.5
Iowa	62.9	184.8	257.8	267.6r	272.3	299.5
Kansas	36.0	227.7	434.4	417.4r	409.9	404.9
Kentucky	41.7	162.8	565.1	564.5r	551.9	599.6
Louisiana	46.9	367.4	685.6	613.4r	576.9	602.6
Maine	26.3	42.9	60.0	55.8r	50.7	57.0
Maryland	39.4	161.7	263.2	227.9r	254.2	255.9
Massachusetts	85.1	184.8	266.0	252.0r	255.0	278.0
Michigan	80.9	387.2	660.1	631.3r	613.1	703.7
Minnesota	54.3	148.5	348.7	326.3r	301.2	340.4
Mississippi	52.8	150.7	256.7	248.7r	228.5	236.1
Missouri	89.0	251.9	488.7	485.7r	493.2	485.6
Montana	23.1	81.4	123.7	122.4r	125.5	148.2
Nebraska	31.5	84.7	151.0	155.0r	105.9	158.5
Nevada	2.5	41.8	95.8	86.9r	102.8	106.8
New Hampshire	21.3	23.1	52.3	52.5r	50.9	52.4
New Jersey	102.5	353.1	521.1	459.7r	419.7	437.6
New Mexico	5.9	101.2	218.3	216.5r	216.1	220.7
New York	276.0	735.9	756.3	683.6r	645.3	709.4
North Carolina	35.8	213.4	468.6	467.8r	428.5	427.7
North Dakota	7.8	44.0	105.8	120.8r	143.9	153.1
Ohio	190.5	678.7	1125.6	1057.5r	1009.0	1073.6
Oklahoma	14.2	261.8	371.3	367.3r	375.9	377.9
Oregon	22.3	126.5	215.5	218.7r	211.4	219.3
Pennsylvania	304.0	811.8	891.8	899.1r	859.1	891.2
Rhode Island	23.3	35.2	35.0	32.9r	29.9	33.4
South Carolina	24.1	99.0	2414.0	242.3r	231.0	258.8
South Dakota	9.2	35.2	68.8	69.7r	65.7	57.7
Tennessee	46.1	193.6	496.4	473.5r	435.0	469.2
Texas	65.9	1304.6	2691.4	2507.1r	2439.7	2457.4

(continued)

Table 3-6c (continued)

State	1900	1950	1977	1980	1984	1987
Utah	8.0	81.4	120.3	129.6r	127.7	184.9
Vermont	18.2	15.4	32.9	34.8r	33.3	36.2
Virginia	44.2	226.6	364.1	334.0r	325.8	360.4
Washington	20.6	130.9	281.0	266.2r	247.3	273.3
West Virginia	26.7	190.3	408.7	403.3r	414.7	417.5
Wisconsin	64.7	154.8	366.8	361.2r	370.2	406.0
Wyoming	7.9	53.9	204.6	212.6r	234.1	261.3

Source: Gschwandtner, G. K. Gschwandtner, K. Eldridge, C. Mann and D. Mobley. 1986. Historic emissions of sulfur and nitrogen oxides in the United States from 1900 to 1980. Journal of the Air Pollution Control Association, vol. 36, no. 2.

Knudson, D.A. 1986. Estimated monthly emissions of sulfur dioxide and oxides of nitrogen for the 49 contiguous states, 1975-1984. ANL/EES-TM-318, vol. 1. Argonne National Laboratory, Argonne, IL.

Kohout, E.J., D.A. Knudson, C.L. Saricks & D.J. Miller. 1987. Estimated monthly emissions of sulfur dioxide, oxides of nitrogen, and volatile organic compounds for the 48 contiguous states, 1985-1986. ANL/EES-TM-335, vol. 1. Argonne National Laboratory, Argonne, IL.

Table 3-7.
Trends in volatile organic compound emissions by source (million metric tons), 1940-1986

Year	Transportation	Fuel combustion	Industrial processes	Non-industrial organic solvent	Solid waste	Miscellaneous	Total
1940	5.2	4.7	3.3	0.8	0.9	3.7	18.6
1950	7.9	3.1	5.4	1.3	1.0	2.3	21.0
1960	11.1	1.9	6.3	1.7	1.4	1.4	23.8
1970	12.4	1.1	8.9	2.3	1.8	1.0	27.5
1975	10.3	1.0	8.1	1.9	0.9	0.6	22.8
1976	10.4	1.2	8.7	1.9	0.8	1.0	24.0
1977	10.0	1.4	9.3r	1.9	0.8	0.8	24.1r
1978	9.7r	1.6	9.9r	1.9	0.8	0.8	24.7r
1979	8.9	1.9	9.8r	2.0	0.7	0.9	24.3r
1980	8.2	2.2r	9.2r	1.9	0.6	1.0	23.0r
1981	7.9r	2.3	8.3r	1.6	0.6	0.9	21.6r
1982	7.4r	2.5	7.4r	1.5	0.6	0.7	20.1r
1983	7.3r	2.6	7.8r	1.6	0.6	1.1	20.9r
1984	7.3r	2.6r	8.7r	1.8	0.6	0.9	21.9r
1985	6.7	2.3	8.4	1.5	0.6	0.7	20.3
1986	6.5	2.3	7.9	1.5	0.6	0.7	19.5

Source: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. 1988. National air quality and emissions trends report, 1986, table 3-5, p. 3-35. EPA-450/4-88-001. Research Triangle Park, NC.

U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, National Air Data Branch. 1988. National air pollutant emission estimates, 1940-1986. table 1, p. 2. EPA-450/4-87-024. Research Triangle Park, N.C.

Table 3-8.
Trends in total suspended particulate emissions by source (million metric tons), 1940-1986

Year	Transportation	Fuel combustion	Industrial processes	Solid waste	Miscellaneous	Total
1940	2.7	7.5	8.7	0.5	3.7	23.1
1950	2.1	7.0	12.7	0.6	2.5	24.9
1960	0.7	5.7	12.5	0.9	1.8	21.6
1970	1.2	4.6	10.5	1.1	1.1	18.5
1975	1.4	2.7	5.0	0.6	0.7	10.4
1976	1.4	2.5	4.4	0.4	1.0	9.7
1977	1.4	2.5	4.0	0.4	0.8	9.1
1978	1.4	2.5r	4.0	0.4	0.8	9.1r
1979	1.4	2.5	3.8	0.4	0.9	8.9r
1980	1.3r	2.4	3.3r	0.4	1.1	8.5
1981	1.3r	2.3r	2.6r	0.4	0.9	8.0r
1982	1.3	2.2	2.4	0.3r	0.7	7.1r
1983	1.3r	2.0r	2.4r	0.3	1.1	7.1r
1984	1.3	2.1r	2.8r	0.3	0.9	7.4r
1985	1.4	1.8	2.8	0.3	0.8	7.0
1986	1.4	1.8	2.5	0.3	0.8	6.8

Source: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. 1988. National air quality and emissions trends report, 1986, table 3-1, p. 3-8. EPA-450/4-88-001. Research Triangle Park, NC.

U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, National Air Data Branch. 1988. National air pollutant emission estimates, 1940-1986. table 1, p. 2. EPA-450/4-87-024. Research Triangle Park, N.C.

Table 3-9.
Trends in carbon monoxide emissions by source (million metric tons), 1940-1986

Year	Transportation	Fuel combustion	Industrial processes	Solid waste	Miscellaneous	Total
1940	29.3	15.9	6.6	3.3	26.5	81.6
1950	43.6	11.4	10.5	4.3	16.5	86.3
1960	57.0	7.0	9.3	5.1	10.0	88.3
1970	71.8	4.4	8.9	6.4	7.2	98.7
1975	62.0	4.4	6.9	3.1	4.8	81.2
1976	64.3	4.7	7.1	2.7	7.1	85.9
1977	61.0r	5.1r	7.3r	2.6	5.8	81.8r
1978	60.3r	5.8	7.2r	2.5	5.7	81.4r
1979	55.9	6.6	7.1	2.3	6.5	78.3r
1980	52.6r	7.3r	6.3	2.2	7.6	76.1r
1981	51.6	7.5	5.9	2.1	6.4	73.4r
1982	48.1	8.0	4.4	2.0	4.9	67.4r
1983	48.3r	7.9r	4.4	1.9	7.7	70.3r
1984	48.4r	8.1r	4.8	1.9	6.3	69.6r
1985	45.2	7.2	4.6	2.0	5.3	64.3
1986	42.6	7.2	4.5	1.7	5.0	60.9

Source: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. 1988. National air quality and emissions trends report, 1986, table 3-3, p. 3-23. EPA-450/4-88-001. Research Triangle Park, NC.

U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, National Air Data Branch. 1988. National air pollutant emission estimates, 1940-1986. table 1, p. 2. EPA-450/4-87-024. Research Triangle Park, N.C.

Table 3-10.
Trends in lead emissions by source (thousand metric tons), 1970-1986

Year	Transportation	Fuel combustion	Industrial processes	Solid waste	Total
1970	163.6	9.6	23.9	6.7	203.8
1975	122.6	9.3	10.3	4.8	147.0
1976	132.4	8.3	8.1	4.3	153.1
1977	124.2	7.2	5.7	4.1	141.2
1978	112.4	6.1	5.4	4.0	127.9
1979	94.6	4.9	5.2	4.0	108.7
1980	59.4	3.9r	3.6	3.7	70.6r
1981	46.4	2.8	3.0	3.7	55.9
1982	46.9	1.7	2.7	3.1	54.4
1983	40.7	0.6	2.4	2.6	46.3
1984	34.7	0.5	2.3	2.6r	40.1
1985	15.5	0.5	2.3	2.8	21.1
1986	3.5	0.5	1.9	2.7	8.6

Source: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. 1988. National air quality and emissions trends report, 1986, table 3-6, p. 3-41. EPA-450/4-88-001. Research Triangle Park, NC.

U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, National Air Data Branch. 1988. National air pollutant emission estimates, 1940-1986. table 1, p. 2. EPA-450/4-87-024. Research Triangle Park, N.C.

Table 4-1a.
Major uses of land (billions of acres), 1910-1982

Year	Cropland	Grassland, range & pasture	Forest land	Other land	Total land area
1910	0.347	0.814	0.562	0.181	1.904
1920	0.402	0.750	0.567	0.185	1.904
1930	0.413	0.708	0.607	0.176	1.904
1940	0.399	0.723	0.602	0.180	1.904
1954	0.399	0.699	0.615	0.191	1.904
1964	0.387	0.697	0.732	0.450	2.266
1974	0.382	0.681	0.718	0.483	2.264
1978	0.395	0.663	0.703	0.503	2.264
1982	0.404	0.662	0.655	0.544	2.265

Source: 1982: Frey, H.T. & R.W. Hexem. 1985. Major uses of land in the United States: 1982. Agricultural Economic Report No. 535, p.3. Natural Resources Economics Division, Economic Research Service, U.S. Department of Agriculture. Washington, D.C.

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Wooten, H.H & J. R. Anderson. 1957. Major uses of land in the United States: Summary for 1954. AIB-168. U.S. Department of Agriculture, Agricultural Research Service. Washington, D.C.

Wooten, H.H., K. Gertel & W.C. Pendleton. 1962. Major uses of land and water in the United States: Summary for 1959. AER-13. U.S. Department of Agriculture, Economic Research Service. Washington, D.C.

Note: The total land area of the United States increased in 1959 with the addition of Alaska and Hawaii as states. Other changes in total land area result from refinement in measuring techniques. Within category changes result from gains and losses from bases. The estimates for different years are not strictly comparable.

Table 4-1b.
Land in special use areas (millions of acres and percentage of total), 1982

Land use	Acreage	Percent
Transportation	27	5.0
Parks	116	21.3
Wildlife	95	18.0
National Defense	24	4.4
Farmsteads	8	2.0
Unclassified	274	50.4

Source: Frey, H.T. & R.W. Hexem. 1985. Major uses of land in the United States: 1982. Agricultural Economic Report No. 535, p. 13. Natural Resources Economics Division, Economic Research Service, U.S. Department of Agriculture, Washington, D.C.

Table 4-1c.
Land ownership (millions of acres and percentage of total), 1982

Ownership	Acreage	Percent
Federal	730	32.2
State	155	6.8
Indian	51	2.3
Private	1329	58.7

Source: Frey, H.T. & R.W. Hexem. 1985. Major uses of land in the United States: 1982. Agricultural Economic Report No. 535, p. 14. Natural Resources Economics Division, Economic Research Service, U.S. Department of Agriculture, Washington, D.C.

Table 4-1d.
Major uses of land by ownership (millions of acres and percentage of total), 1982

Ownership	Cropland		Grassland		Forest		Miscellaneous	
	Acreage	Percent	Acreage	Percent	Acreage	Percent	Acreage	Percent
Federal	1	0.21	150	25.13	210	32.06	369	67.83
State	2	0.43	41	6.87	39	5.95	73	13.42
Indian	2	0.43	33	5.53	13	1.98	3	0.55
Private	464	98.93	373	62.48	393	60.00	99	18.20

Source: Frey, H.T. & R.W. Hexem. 1985. Major uses of land in the United States: 1982. Agricultural Economic Report No. 535, p.14. Natural Resources Economics Division, Economic Research Service. U.S. Department of Agriculture. Washington, D.C.

Table 4-1e.
Land use patterns by region (percentage of land area), 1982

Region	Cropland	Pasture	Forest	Other
Northeast	15	2	65	18
Lake States	37	4	41	18
Corn Belt	61	8	17	14
Northern Plains	55	36	2	7
Appalachian	25	5	58	12
Southeast	16	9	59	16
Delta States	27	8	52	13
Southern Plains	26	58	10	6
Mountain States	8	56	22	14
Pacific States	12	26	45	17
Alaska	*	*	33	67
Hawaii	7	27	37	29

Source: Frey, H.T. & R.W. Hexem. 1985. Major uses of land in the 1982. Agricultural Economic Report, No. 535, p. 4. Natural Resources Economics Division, Economic Research Service, U.S. Department of Agriculture. Washington, D.C.

Note: *=Less than 0.5 percent.

Table 4-2b.
Number of farms (millions) and land in farms (billions of acres), 1860-1982

Year	Farms	Land
1860	2.00	NA
1880	4.00	NA
1890	4.57	NA
1900	5.74	0.84
1910	6.37	0.88
1920	6.45	0.96
1925	6.37	NA
1930	6.30	0.99
1935	6.81	NA
1940	6.10	1.07
1945	5.86	1.14
1950	5.39	1.16
1954	4.78	1.16
1959	3.71	1.12
1964	3.16	1.11
1969	2.73	1.06
1974	2.31	1.02
1978	2.26	1.02
1982	2.24	0.99

Source: U.S. Department of Commerce, Bureau of the Census. 1976. Historical statistics of the United States: Colonial times to 1970, part I, series K 109 & 142. Washington, D.C.

U.S. Department of Commerce, Bureau of the Census. 1985. Statistical abstracts of the United States: 1986, table 1122, p. 636. Washington, D.C.

Table 4-2c.
Number of farms by tenure type (millions), 1900-1982

Year	Full owner	Part owner	Tenant	Manager
1900	3.203	0.452	2.026	0.059
1910	3.356	0.594	2.358	0.058
1920	3.368	0.559	2.459	0.069
1925	3.314	0.555	2.463	0.041
1930	2.913	0.657	2.669	0.056
1935	3.210	0.689	2.865	0.048
1940	3.085	0.616	2.365	0.037
1945	3.301	0.661	1.858	0.039
1950	3.092	0.826	1.448	0.024
1954	2.745	0.868	1.149	0.021
1959	2.117	0.834	0.736	0.021
1964	1.818	0.782	0.540	0.018
1969	1.706	0.672	0.353	NA
1974	1.424	0.628	0.262	NA
1978	1.298	0.681	0.279r	NA
1982	1.326	0.656	0.259	NA

Source: U.S. Department of Commerce, Bureau of the Census. 1976. Historical statistics of the United States: Colonial times to 1970, part I, series K 109-113. Washington, D.C.

U.S. Department of Commerce, Bureau of the Census. 1985. Statistical abstracts of the United States: 1986, table 1123, p. 636. Washington, D.C.

Note: No adjustments have been made to account for different definitions of a farm.

Table 4-2d.
Number of farms by farm size (millions), 1900-1982

Year	1-49 acres	50-499 acres	500-999 acres	1000+ acres
1900	1.934	3.367	0.103	0.047
1910	2.253	3.933	0.125	0.050
1920	2.305	3.932	0.150	0.067
1925	2.417	3.748	0.144	0.063
1930	2.364	3.690	0.160	0.081
1935	2.694	3.862	0.167	0.089
1940	2.291	3.546	0.164	0.101
1945	2.250	3.323	0.174	0.113
1950	1.968	3.116	0.182	0.121
1954	1.696	2.763	0.192	0.130
1959	1.057	2.318	0.200	0.135
1964	0.820	1.981	0.210	0.145
1969	0.635	1.728	0.216	0.151
1974	0.508	1.444	0.207	0.155
1978	0.543	1.341	0.213	0.161
1982	0.637	1.238	0.204	0.162

Source: U.S. Department of Commerce, Bureau of the Census. 1976. Historical statistics of the United States: Colonial times to1970, part I, series K 109-113. Washington, D.C.

U.S. Department of Commerce, Bureau of the Census. 1985. Statistical abstracts of the United States: 1986, table 1122, p. 636. Washington, D.C.

Table 4-2e.
Land in farms by tenure type (millions of acres), 1900-1982

Year	Full owner	Part owner	Tenant
1900	431	125	314
1910	465	134	280
1920	461	176	342
1930	373	247	403
1940	382	301	405
1945	412	371	377
1950	419	423	334
1954	397	472	300
1959	346	504	278
1964	319	533	258
1969	375	550r	138
1974	359	535	122
1978	332	561	122
1982	343r	531	114

Source: U.S. Department of Commerce, Bureau of the Census. 1976. Historical statistics of the United States: Colonial times to 1970, part I, series K 142-147. Washington, D.C.

U.S. Department of Commerce, Bureau of the Census. 1986. Statistical abstracts of the United States: 1987, table 1100, p. 622. Washington, D.C.

Table 4-2f.
Land in farms by farm size (millions of acres), 1900-1982

Year	1-49 acres	50-499 acres	500-999 acres	1000+ acres
1900	49	520	68	200
1910	49	570	84	167
1920	59	580	100	221
1925	57	550	97	224
1930	56	550	109	277
1935	59	540	114	310
1940	50	540	112	366
1945	47	520	119	460
1950	39	500	126	495
1954	32	460	132	531
1959	22	410	137	555
1964	17	360	145	585
1969	14	320	148	578
1974	11	273	142	590
1978	12r	256r	147	600
1982	13	233	141	600

Source: U.S. Department of Commerce, Bureau of the Census. 1976. Historical statistics of the United States: Colonial times to 1970, part I, series K 142-147. Washington, D.C.

U.S. Department of Commerce, Bureau of the Census. 1986. Statistical abstracts of the United States: 1987, table 1099, p. 622. Washington, D.C.

Table 4-3b.
Use of prime farmland (millions of acres), 1967-1982

Use	1967	1975	1977	1982
Cropland	NA	250	230	233
Pasture	NA	NA	40	39
Rangeland	NA	NA	22	20
Forest land	NA	NA	42	45
Other land	NA	20	11r	7
Total	392	384	345r	344

Source: Schmude, K.O. 1977. A perspective on prime farmland. Journal of Soil and Water Conservation 32: 241.

Source: U.S. Department of Agriculture, Soil Conservation Service & Iowa State University Statistical Laboratory. 1982. Basic statistics: 1977 natural resources inventory, table 17, p. 59. Statistical Bulletin 686. Washington, D.C.

U.S. Department of Agriculture, Soil Conservation Service & Iowa State University Statistical Labortory. 1987. Basic statistics: 1982 natural resources inventory, table 40a, p. 62. Statistical Bulletin 756. Washington, D.C.

Table 4-4a.
Major uses of cropland (millions of acres), 1945-1987

Year	Harvested	Failed	Summer fallow	Idle	Cropland pasture	Total
1945	353	10	40	NA	47	454
1949	352	9	26	22	67	478
1954	339	13	28	19	66	465
1959	317	10	31	33	66	457
1964	292	6	37	52	57	444
1969	286	6	41	51	88	472
1974	322	8	31	21	83	465
1978	330	7	32	26	76	471
1982	347	5	31	21	65	469
1986	316	8	32	NA	NA	NA
1987	293	6	32	NA	NA	NA

Source: U.S. Department of Agriculture, Economic Research Service. 1988. Cropland, water, and conservation situation and outlook report, table 1, p. 5. AR-12 and earlier issues. Washington, D.C.

Note: Acres of idle cropland, cropland pasture, and total cropland are estimated only for years coinciding with Census of Agriculture years. Data are for the 48 conterminous states.

Table 4-4b.
Cropland diverted from production under federal farm programs (millions of acres), 1956-1987

Year	Diverted cropland	Year	Diverted cropland	Year	Diverted cropland
1956	13.6	1967	40.2	1978	18.3
1957	27.8	1968	48.9	1979	13.0
1958	27.1	1969	57.5	1980	0.0
1959	22.5	1970	57.0	1981	0.0
1960	28.7	1971	37.6	1982	11.1
1961	53.7	1972	61.6	1983	77.8r
1962	64.7	1973	19.6	1984	27.0r
1963	56.0	1974	2.7	1985	30.7
1964	55.0	1975	2.4	1986	48.1r
1965	56.0	1976	2.1	1987	75.5
1966	62.8	1977	1.0		

Source: U.S. Department of Agriculture, Economic Research Service. 1988. Cropland, water, and conservation situation and outlook report, table 4, p. 8. AR-12. Washington, D.C.

Table 4-5a.
Agricultural productivity (indexed 1977=100), 1969-1987

Year	Input	Output	Productivity
1969	97	85	88
1970	97	84	87
1971	98	92	94
1972	97	91	94
1973	98	93	95
1974	98	88	90
1975	96	95	99
1976	99	97	98
1977	100	100	100
1978	102	104r	102
1979	105	111	109
1980	103	104	101
1981	102	118	116
1982	99	116	118r
1983	97r	96r	99r
1984	95r	112	118r
1985	92r	118r	128r
1986	87	111	127
1987	NA	109p	NA

Source: U.S. Department of Agriculture, Economic Research Service. 1988. Economic indicators of the farm sector: Production and efficiency statistics, 1986 (updated). Washington, D.C.

Table 4-5b.
Farm fuel use (billions of gallons), 1974-1987

Year	Gasoline	Diesel	LP gas
1974	3.7	2.6	1.4
1975	4.5	2.4	1.0
1976	3.9	2.8	1.2
1977	3.8	2.9	1.1
1978	3.6	3.2	1.3
1979	3.4	3.2	1.1
1980	3.0	3.2	1.1
1981	2.7	3.1	1.0
1982	2.4	2.9	1.1
1983	2.3	3.0	0.9
1984	2.1	3.0	0.9
1985	1.9	2.9	0.9
1986	1.7r	2.9	0.7
1987	1.5	3.0	0.6

Source: U.S. Department of Agriculture, Economic Research Service. 1988. Agricultural resources inputs situation and outputs report, table 13, p. 15. AR-11. Washington, D.C.

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Table 4-5c.
Farm inputs (indexed 1977=100), 1969-1985

Year	Farm labor	Mechanical power & machinery	Agricultural chemicals	Total input
1969	118	86	73	97
1970	112	85	75	97
1971	108	87	81	98
1972	110	86	86	97
1973	109	90	90	98
1974	109	92	92	98
1975	106	96	83	96
1976	100	98	96	99
1977	100	100	100	100
1978	100	104	107	102
1979	99	104	123	105
1980	96	101	123	103
1981	96	98	129	102
1982	93	94	118	99
1983	97	89	105	95
1984	92	88	121	96
1985	85	83	123	94

Source: U.S. Department of Agriculture, Economic Research Service. Economic indicators of the farm sector: production and efficiency statistics, annual. Washington, D.C.

Note: Agricultural chemicals includes fertilizer, lime and pesticides.

Table 4-5d.
Farm fertilizer use (millions of tons of primary nutrients), 1939-1987

Year	Fertilizer applied	Year	Fertilizer applied	Year	Fertilizer applied
1939	1.6	1956	6.1	1973	18.0
1940	1.8	1957	6.4	1974	19.3
1941	1.9	1958	6.5	1975	17.6
1942	2.1	1959	7.4	1976	20.8
1943	2.4	1960	7.5	1977	22.1
1944	2.6	1961	7.8	1978	20.6
1945	2.7	1962	8.4	1979	22.6
1946	3.1	1963	9.5	1980	23.1
1947	3.3	1964	10.5	1981	23.7
1948	3.6	1965	11.0	1982	21.4
1949	3.9	1966	12.4	1983	18.1
1950	4.1	1967	14.0	1984	21.8
1951	4.7	1968	15.0	1985	21.7
1952	5.2	1969	15.5	1986	19.7r
1953	5.6	1970	16.1	1987	19.2
1954	5.9	1971	17.2		
1955	6.1	1972	17.2		

Source: U.S. Department of Commerce, Bureau of the Census. 1976. Historical statistics of the United States: Colonial times to 1970, series K 193. Washington, D.C.

U.S. Department of Commerce, Bureau of the Census. 1985. Statistical abstracts of the United States: 1986, no. 1161, p. 654. Washington, D.C.

U.S. Department of Agriculture, Economic Research Service. 1988. Inputs situation and outlook report, table 6, p. 10. AR-9. Washington, D.C.

Note: Primary nutrients include nitrogenous, phosphate and potash fertilizers.

Table 4-5e.
Pesticide use (million pounds of active ingredients), 1964-1987

Year	Herbicides	Insecticides	Other	Total
1964	76	143	72	291
1966	112	138	78	328
1971	207	127	130	464
1976	374	130	146	650
1982	451	71	30	552
1986	410	59	6	475
1987	365	57	7	429

Source: 1964: U.S. Department of Agriculture, Economic Research Service. 1968. Quantities of pesticides used by farmers in 1964, pp. 19-27. AR-131. Washington, D.C.

1968: U.S. Department of Agriculture, Economic Research Service. 1970. Quantities of pesticides usec by farmers in 1968, pp.22-23. AR-179. Washington, D.C.

1971: U.S. Department of Agriculture, Economic Research Service. 1977. Quantities of pesticides used by farmers in 1971, pp. 9-50. AR-252.Washington, D.C.

1976: U.S. Department of Agriculture, Economic Research Service. 1979. Quantities of pesticides used by farmers in 1976, pp. 9-52. AR-252. Washington, D.C.

1982: U.S. Department of Agriculture, Economic Research Service. 1983. Inputs situation and outlook report. IOS-2. Washington, D.C.

1986: U.S. Department of Agriculture, Economic Research Service. 1987. Inputs situation and outlook report, table 14, p. 16 (updated). AR-5. Washington, D.C.

1987: U.S. Department of Agriculture, Economic Research Service. 1988. Inputs, situation and outlook report, p. 16. AR-9. Washington, D.C.

Note: For the year 1964, 1966, 1972, and 1976, estimates of pesticide use are for total use on all crops and livestock in the United States. The 1982 estimates are for major field and forage crops only and represent 33 major producing states excluding California. The 1986 and 1987 estimates are for the 10 major field crops.

Table 4-5f.
Total irrigated farmland (millions of acres), 1900-1984

Year	17 major irrigating states	31 other states	Total
1890	4	0	4
1900	8	0	8
1910	11	1	12
1920	14	0	14
1930	14	1	15
1940	17	1	18
1945	19	2	21
1950	24	2	26
1954	27	3	30
1959	31	2	33
1964	33	4	37
1969	35	4	39
1974	37	4	41
1978	44	6	50
1982	42	7	49
1984	38	7	45

Source: U.S. Department of Commerce, Bureau of the Census. 1976. Historical statistics of the United States: Colonial times to 1970, part I, series J 86. Washington, D.C.

1974-1982: U.S. Department of Commerce, Bureau of the Census. 1985. Statistical abstracts of the United States: 1986, no. 1131, p. 640. Washington, D.C.

1984: U.S. Department of Commerce, Bureau of the Census. 1986. 1984 farm and ranch irrigation survey. AG84-SR-1. Washington, D.C.

Note: Data are for the 48 conterminous states.

Table 4-5g.
Water used for irrigation (billions of gallons per day), 1900-1985

Year	Water use
1900	20
1910	39
1920	56
1930	60
1940	71
1950	89
1955	110
1960	110
1965	120
1970	130
1975	140
1980	150
1985	140r

Source: U.S. Department of Commerce, Bureau of the Census. 1976. Historical statistics of the United States: Colonial times to 1970, part I, series J 94. Washington, D.C.

U.S. Department of Commerce, Bureau of the Census. 1986. Statistical abstracts of the United States: 1987, no. 327, p. 186. Washington, D.C.

Solley, W.B., C.F. Merk & R.R. Pierce. 1988. Estimated use of water in the United States in 1985. U.S. Department of the Interior, Geological Survey Circular 1004, p. 69. Reston, VA.

Note: Estimates for years 1900-1940 are for conterminous United States only.

Table 4-5h.
Water applied to irrigated acres (annual average acre-feet applied per acre), 1969-1984

Year	Application
1969	2.11
1974	2.09
1979	1.86
1984	1.80

Source: U.S. Department of Commerce, Bureau of the Census. 1986. 1984 farm and ranch irrigation survey. AG84-SR-1. Washington, D.C.

Table 4-6d.
Ownership of land suitable for grazing (millions of acres and percentage of suitable acreage), mid-1980s

Ownership	Acreage	Percent
Forest Service	51.35	4.8
Bureau of Land Management	162.46	15.1
Other federal	258.84	24.0
Nonfederal	605.38	56.2

Source: U.S. Department of Agriculture, Forest Service. 1987. Condition of U.S. Forest Service rangelands as of 1987, table 2. Ecological status-suitable acres. Washington, D.C.

U.S. Department of the Interior, Bureau of Land Management. 1988. Public land statistics, 1987. Washington, D.C.

U.S. Department of Agriculture, Soil Conservation Service & Iowa State University Statistical Laboratory. 1987. Basic statistics: 1982 natural resources inventory, table 2a, p. 24. Statistical Bulletin 756. Washington, D.C.

Table 4-7a.
Condition of nonfederal rangeland (percentage of total acreage), 1963-1982

Condition	1963	1977	1982
Excellent	5	12	9
Good	15	28	30
Fair	40	42	45
Poor	40	18	16

Source: U.S. Department of Agriculture, Soil Conservation Service. 1982. Basic statistics 1977. Natural resources inventory. USDA/SCS Statistical Bulletin 686. Washington, D.C.

U.S. Department of Agriculture, Soil Conservation Service. 1986. Basic statistics 1982. Natural resources inventory, table 2a. Land cover/use of nonfederal land and small water in 1982, by state. Washington, D.C.

Table 4-7b.
Condition of Bureau of Land Management grazed rangeland (percentage of classified acreage), 1936-1987

Condition	1936	1966	1975	1986	1987
Excellent	1.5	2.2	2	4	3
Good	14	16.7	15	30	30
Fair	48	51.6	50	41	39
Poor	36	29.5	33	18	19

Source: U.S. Department of the Interior, Bureau of Land Management. 1988. Public land statistics, 1987. Washington, D.C.

Table 4-7c.
Ecological status and forage conditions of Forest Service grazing lands (percentage of total acreage), 1986

Category	Satisfactory	Unsatisfactory
Natural potential	14	0
Late seral	31	2
Mid seral	28	10
Early seral	7	8

Source: U.S. Department of Agriculture, Forest Service. 1987. Condition of U.S. Forest Service rangelands as of 1987, table 2. Ecological status-suitable acres. Washington, D.C.

Table 4-7d.
Apparent trend in nonfederal rangeland condition (millions of acres and percentage of total acreage), 1982

Trend	Acreage	Percent
Toward potential	43.7	11
Away from potential	60.1	16
Not apparent/stable	282.1	73

Source: U.S. Department of Agriculture, Soil Conservation Service. 1986. Basic statistics 1982. Natural resources inventory, table 2a. Land cover/use of nonfederal land and small water in 1982, by state. Washington, D.C.

Table 4-7e.
Apparent trend in Bureau of Land Management grazed rangeland condition (millions of acres and percentage of total acreage), 1987

Trend	Acreage	Percent
Toward potential	23.7	15
Away from potential	23.0	14
Not apparent/static	103.0	63
Undetermined	13.3	8

Source: U.S. Department of the Interior, Bureau of Land Management. 1987. Range condition and trend report, table 4, p. 6. Washington, D.C.

Table 4-7f.
Apparent trend in ecological status of Forest Service suitable grazing land condition (millions of acres and percentage of suitable acreage), 1986

Trend	Acreage	Percent
Towards potential	21.6	43
Away from potential	6.8	13.5
Not apparent/static	21.9	43.5

Source: U.S. Department of Agriculture, Forest Service. 1987. Condition of U.S. Forest Service rangelands as of 1987, table 3. Regional summary trend of suitable acres-1987. Washington, D.C.

Table 4-9.
Ownership of forest land (percentage of total forest land area), 1982

Ownership	Percentage
Forest Service	19.5r
Bureau of Land Mgmt.	3.7r
Other Federal	6.0r
Nonfederal	70.8r

Source: U.S. Department of Agriculture, Forest Service. 1989. The 1989 assessment of the forest and rangeland situation in the United States. Washington, D.C.

U.S. Department of Agriculture, Soil Conservation Service. 1986. Soil, water, and related resources of the United States: Status, conditions, and trends. Draft appraisal, part I. Washington, D.C.

Table 4-10a.
Reforestation (millions of acres planted and directly seeded), 1930-1987

Year	Acreage	Year	Acreage	Year	Acreage
1930	0.14	1962	1.37	1976	1.89
1940	0.52	1963	1.33	1977	1.98
1950	0.50	1964	1.31	1978	2.09
1951	0.45	1965	1.29	1979	2.06
1952	0.52	1966	1.28	1980	2.27
1953	0.71	1967	1.37	1981	1.93
1954	0.81	1968	1.44	1982	2.37
1955	0.78	1969	1.43	1983	2.45
1956	0.89	1970	1.60	1984	2.55
1957	1.14	1971	1.69	1985	2.70
1958	1.53	1972	1.68	1986	2.75
1959	2.12	1973	1.75	1987	3.03
1960	2.14	1974	1.60		
1961	1.76	1975	1.93		

Source: U.S. Department of Agriculture, Forest Service. U.S. forest planting report, annual. Washington, D.C.

Table 4-10b.
Reforestation by ownership (thousands of acres and percentage of reforested acreage), 1987

Owner	Acreage	Percentage
Federal government	333.51	11.0
State and local government	70.73	2.3
Forest industry	1312.97	43.3
Other industry	25.65	0.8
Nonindustry private	1290.36	42.5

Source: U.S. Department of Agriculture, Forest Service. 1988. 1987 U.S. forest planting report, p. 4. Washington, D.C.

Table 4-11.
Forest land damaged by wildfire (millions of acres), 1926-1987

Year	Acres	Year	Acres	Year	Acres
1926	24.3	1947	23.2	1968	4.2
1927	38.5	1948	16.6	1969	6.7
1928	43.5	1949	15.4	1970	3.3
1929	46.2	1950	15.5	1971	4.3
1930	52.3	1951	10.8	1972	2.6
1931	51.6	1952	14.2	1973	1.9
1932	42.1	1953	10.0	1974	2.9
1933	43.9	1954	8.8	1975	1.8
1934	41.8	1955	8.1	1976	5.1
1935	30.3	1956	6.6	1977	3.2
1936	43.2	1957	3.4	1978	3.9
1937	21.9	1958	3.3	1979	3.0
1938	33.8	1959	4.2	1980	5.3
1939	30.5	1960	4.5	1981	4.8
1940	25.9	1961	3.0	1982	2.4
1941	26.4	1962	4.1	1983	5.1
1942	31.9	1963	7.1	1984	3.0
1943	32.3	1964	4.2	1985	5.2
1944	16.5	1965	2.7	1986	3.2
1945	17.7	1966	4.6	1987	5.0
1946	20.7	1967	4.7		

Source: U.S. Department of Agriculture, Forest Service. Wildfire statistics, annual. Washington, D.C.

Table 4-12a.
Forest land damaged by insects (millions of acres), 1968-1987

Year	Eastern spruce budworm	Western spruce budworm	Gypsy moth	Mountain pine beetle	Southern pine beetle
1968	1.3	5.3	0.1	NA	NA
1969	1.2	4.6	0.3	NA	NA
1970	2.0	4.0	1.0	NA	NA
1971	1.6	4.8	1.9	NA	NA
1972	2.8	5.5	1.4	NA	NA
1973	4.2	4.4	1.8	NA	NA
1974	10.8	5.5	0.8	NA	NA
1975	9.2	5.3	0.5	NA	NA
1976	9.1	5.8	0.9	NA	NA
1977	10.3	6.5	1.6	NA	NA
1978	7.7	5.2	1.3	4.0	NA
1979	6.6	5.0	0.6	4.4	15.0
1980	6.6	4.0	5.0	4.7	12.1
1981	4.5	5.5	12.9	4.7	0.9
1982	4.2	8.7	8.2	4.2	7.3
1983	6.5	11.0	2.4	3.6	11.4
1984	6.1	10.6	1.0	3.3	NA
1985	5.2	12.8	1.7	3.3	15.5
1986	1.0	13.2	2.4	3.5	26.4
1987	0.8	8.0	1.3	2.4	13.8

Source: U.S. Department of Agriculture, Forest Service, Forest Pest Management. 1985. Insect and disease conditions in the United States 1979-1983. Washington, D.C.

U.S. Department of Agriculture, Forest Service, Forest Pest Managment. Forest insect and disease conditions in the United States 1985; 1986; 1987. Washington, D.C.

Table 4-12b.
Defoliation by gypsy moth (percentage of cumulative area defoliated), 1924-1987

Year	Percentage
1924-1979 (cumulative)	45
1980	10
1981	25
1982	15
1983	5
1984	2
1985	3
1986	4
1987	2

Source: U.S. Department of Agriculture, Forest Service, Forest Pest Management. 1985. Insect and disease conditions in the United States 1979-1983. Washington, D.C.

U.S. Department of Agriculture, Forest Service, Forest Pest Management. Forest insect and disease conditions in the United States 1985; 1986; 1987. Washington, D.C.

Table 4-12c.
Infestation by disease (millions of acres and percentage of infested acreage), 1987

Disease	Acreage	Percentage
Fusiform rust	15.30	29
Dwarf mistletoe	21.84	42
Root disease	15.08	29

Source: U.S. Department of Agriculture, Forest Service, Forest Pest Management. 1985. Insect and disease conditions in the United States 1979-1983. Washington, D.C.

U.S. Department of Agriculture, Forest Service, Forest Pest Management. Forest insect and disease conditions in the United States 1985; 1986; 1987. Washington, D.C.

Table 4-13a.
Net annual growth of growing stock by ownership (billion cubic feet per year), 1952-1986

Year	Farmer and other private	Forest industry	National forests	Other public
1952	8.1	2.6	2.1	1.2
1962	9.5	3.2	2.5	1.6
1970	11.3	3.7	2.9	1.9
1976	12.6	4.2	3.1	2.0
1986	12.4	4.4	3.3	2.3

Source: U.S. Department of Agriculture, Forest Service, 1989. The 1989 RPA Assessment of the forest and rangeland situation in the United States. Washington, D.C.

Table 4-13b.
Annual removals of growing stock by ownership (billion cubic feet per year), 1952-1986

Year	Farmer and other private	Forest Industry	National forests	Other public
1952	6.9	3.3	1.1	0.6
1962	6.4	3.0	1.9	0.7
1970	7.0	3.8	2.3	1.0
1976	6.8	4.2	2.1	1.1
1986	8.2	5.4	2.2	1.2

Source: U.S. Department of Agriculture, Forest Service, 1989. The 1989 RPA Assessment of the forest and rangeland situation in the United States. Washington, D.C.

U.S. Department of Agriculture, Forest Service, 1978. Forest statistics of the United States, 1977. Washington, D.C.

Table 4-13c.
Net annual growth and removals by region (billion cubic feet per year), 1952-1986

Year	North Growth	North Removals	South Growth	South Removals
1952	3.8	2.1	6.7	5.7
1962	4.5	2.1	8.1	5.5
1970	5.0	2.5	9.9	6.0
1976	5.4	2.7	11.3	6.7
1986	5.6	2.8	10.4	8.7

Year	Rocky Mountain Growth	Rocky Mountain Removals	Pacific Coast Growth	Pacific Coast Removals
1952	1.1	0.5	2.3	3.5
1962	1.3	0.7	2.8	3.6
1970	1.5	0.9	3.4	4.2
1976	1.6	0.8	3.5	4.2
1986	2.0	0.8	4.3	4.8

Sources: U.S. Department of Agriculture, Forest Service, 1989. The 1989 RPA Assessment of the forest and rangeland situation in the United States. Washington, D.C.

U.S. Department of Agriculture, Forest Service, 1978. Forest statistics of the United States, 1977. Washington, D.C.

Table 4-14.
Roundwood harvest by product (billions of cubic feet), 1950-1986

Year	Lumber	Plywood & veneer	Pulp products	Fuel	Misc.	Total
1950	5.9	0.3	1.5	2.3	0.8	10.8
1951	5.8	0.4	1.8	2.2	0.7	11.0
1952	5.8	0.4	1.8	2.0	0.7	10.8
1953	5.7	0.5	1.9	1.9	0.7	10.7
1954	5.6	0.5	2.0	1.8	0.7	10.6
1955	5.8	0.6	2.2	1.7	0.7	11.0
1956	5.9	0.6	2.5	1.7	0.6	11.3
1957	5.1	0.6	2.4	1.6	0.6	10.2
1958	5.2	0.6	2.2	1.5	0.6	10.0
1959	5.7	0.7	2.4	1.4	0.6	10.8
1960	5.1	0.7	2.6	1.3	0.6	10.2
1961	4.9	0.8	2.5	1.2	0.6	10.0
1962	5.1	0.8	2.6	1.1	0.6	10.2
1963	5.4	0.9	2.7	1.1	0.7	10.6
1964	5.6	1.0	2.9	1.0	0.7	11.2
1965	5.7	1.0	3.1	0.9	0.8	11.5
1966	5.6	1.0	3.2	0.8	0.8	11.5
1967	5.3	1.0	3.2	0.8	0.9	11.2
1968	5.5	1.1	3.4	0.7	1.0	11.8
1969	5.4	1.1	3.6	0.6	1.0	11.6
1970	5.2	1.0	3.8	0.5	1.0	11.6
1971	5.4	1.2	3.6	0.5	0.9	11.5
1972	5.5	1.3	3.5	0.5	1.1	11.9
1973	5.7	1.3	3.8	0.5	1.2	12.4
1974	5.1	1.1	4.2	0.5	1.1	12.1
1975	4.9	1.2	3.5	0.6	1.0	11.1
1976	5.6	1.4	3.8	0.6	1.2	12.5
1977	5.9	1.4	3.6	1.0	1.2	13.2
1978	6.2	1.5	3.7	1.6	1.2	14.1
1979	6.1	1.4	4.1	2.3	1.4	15.2
1980	5.3	1.2	4.4	3.2	1.2	15.3
1981	4.6	1.2	4.1	3.2	0.9	14.1
1982	4.6	1.1	4.0	3.5	1.1	14.3
1983	5.4	1.4	4.2	3.4	1.1	15.4
1984	5.8	1.4	4.4	3.9r	1.2	16.2
1985	5.7	1.4	4.2	4.1	1.2	16.5
1986	6.5p	1.5p	4.5p	4.1p	1.2p	17.8p

Source: U.S. Department of Agriculture, Forest Service. 1988. U.S. timber production, trade, consumption, and price statistics, 1950-1986, table 4, p. 13. Washington, D.C.

Table 5-3a.
Wetlands status and trends (millions of acres), 1954-1974

Wetlands category	1954 acreage	1974 acreage	Net change 1954-1974
Estuarine wetlands	5.59	5.22	-0.37
Freshwater marshes	33.07	28.40	-4.67
Freshwater shrub wetlands	11.00	10.60	-0.40
Freshwater forested wetlands	55.09	49.70	-5.99
Other freshwater wetlands	2.70	5.00	+2.30
Total	107.95	98.92	-9.03

Source: Frayer, W.E., T.J. Monahan, D.C. Bowden & F.A. Graybill. 1983. Status and trends of wetlands and deepwater habitats in the conterminous United States, 1950s to 1970s, table 1, pp. 20, 21. Department of Forest and Wood Sciences, Colorado State University. Ft. Collins, CO.

Tiner, R.W. 1984. Wetlands of the United States: Current status and recent trends, fig. 26, p. 29. U.S. Department of the Interior, Fish and Wildlife Service. Washington, D.C.

Table 5-3b.
Status of wetlands by ownership (millions of acres and percentage of total wetland area), 1985

Ownership	Acreage	Percentage
Private	70.3	74
Federal government	12.5	13
State government	10.4	11
Local government	1.8	2
Total	95.0	100

Source: U.S. Department of the Interior, Fish and Wildlife Service (data compiled by D. Pierce). 1986. Washington, D.C.

Table 5-3c.
Trend in wetland acreages for the conterminous United States (millions of acres and percentage of original wetlands remaining), 1700s-1980s

Time period	Acreage	Percentage
1700s	215	100
1950s	108	50
1970s	99	46
1980s	95	44

Source: Roe, H.B. & Q.A. Ayres. 1954. Engineering for agricultural drainage. McGraw-Hill, New York.

Frayer, W.E., T.J. Monahan, D.C. Bowden & F.A. Graybill. 1983. Status and trends of wetlands and deepwater habitats in the conterminous United States, 1950s to 1970s, table 1, pp. 20, 21. Department of Forest and Wood Sciences, Colorado State University. Fort Collins, CO.

U.S. Department of the Interior, Fish and Wildlife Service, National Wetlands Inventory, unpublished data for the 1980s. Washington, D.C

Table 5-3e.
Conversion of wetlands to other land uses (millions of acres and percentage of wetlands area converted), 1954-1974

Land use after conversion	Acreage	Percentage
Agriculture	9.86	87
Urban	0.91	8
Other	0.57	5
Total	11.34	100

Source: Frayer, W.E., T.J. Monahan, D.C. Bowden & F.A. Graybill. 1983. Status and trends of wetlands and deepwater habitats in the conterminous United States, 1950s to 1970s, table 1, pp. 20, 21. Department of Forest and Wood Sciences, Colorado State University. Fort Collins, CO.

Table 5-4b.
Losses of bottomland hardwood forests in the Mississippi River alluvial plain (millions of acres), 1937-1982

Year	Acreage	Year	Acreage	Year	Acreage
1937	12.35	1957	10.62	1974	7.66
1947	11.36	1967	8.89	1982	6.92

Source: MacDonald, P.O., W.E. Frayer & J.K. Clauser. 1979. Documentation, chronology and future projections of bottomland hardwood loss in the Lower Mississippi alluvial plain, vol. 1. U.S. Department of the Interior, Fish and Wildlife Service, Washington, D.C.

U.S. Department of the Interior, Fish and Wildlife Service, National Wetlands Inventory, unpublished data. 1986. Washington, D.C.

Table 5-4c.
Wetland losses by selected type (millions of acres and percentage of wetland area), 1700s-1980s

Wetland type	Original acreage	Remaining acreage	Percentage lost
Prairie potholes (ND, SD, MN, IA)	15 to 17	5.63r	NA
Great Lakes states	40.100	19.650	51
California	5.000	0.450	91
Rainwater basin	0.094	0.008	91
North Carolina pocosins	2.500	1.500	40
Connecticut coastal	0.030	0.015	20

Source: U.S. Department of the Interior, Fish and Wildlife Service, National Wetlands Inventory, unpublished data. 1986. Washington, D.C.

Note: Data for the prairie potholes were revised by T.E. Dahl (in manuscript), U.S. Fish and Wildlife Service, National Wetlands Inventory. Washington, D.C.

Table 5-5a.
Changes in bird populations of wetland habitats (indexed number of birds per survey route), 1970-1985

Year	Black tern	Pied-billed grebe
1970	5.63	0.84
1971	5.06	0.69
1972	5.25	0.80
1973	6.29	0.68
1974	4.08	0.79
1975	4.30	1.02
1976	4.78	0.71
1977	4.20	0.53
1978	4.04	0.64
1979	3.38	0.67
1980	3.28	0.91
1981	3.31	0.76
1982	3.88	0.64
1983	3.15	0.70
1984	1.82	0.70
1985	2.18	0.65

Source: U.S. Department of the Interior, Fish and Wildlife Service, Office of Migratory Bird Management. 1987. Migratory nongame birds of management concern: The 1987 list. Washington, D.C.

Table 5-5b.
Changes in bird populations of grassland habitats (indexed number of birds per survey route), 1970-1985

Year	Grasshopper sparrow	Lark sparrow	Upland sandpiper	Lark bunting
1970	5.01	7.31	2.65	7.31
1971	5.31	7.92	2.53	6.13
1972	5.08	8.44	2.34	5.81
1973	4.05	6.82	2.45	5.11
1974	3.93	7.20	2.56	5.00
1975	4.33	6.91	2.55	5.47
1976	3.66	6.33	2.38	3.84
1977	4.00	6.07	3.06	4.56
1978	3.37	5.84	2.62	4.48
1979	4.43	5.72	2.93	4.53
1980	4.15	5.42	3.06	4.42
1981	4.39	5.78	3.15	5.70
1982	3.95	6.04	2.92	4.68
1983	3.47	4.71	2.89	4.69
1984	3.22	6.23	3.31	4.60
1985	3.39	5.66	3.60	3.68

Source: U.S. Department of the Interior, Fish and Wildlife Service, Office of Migratory Bird Management. 1987. Migratory nongame birds of management concern: The 1987 list. Washington, D.C.

Table 5-5c.
Changes in bird populations of forest habitats (indexed number of birds per survey route), 1970-1985

Year	Wood thrush	Bluejay	Yellow-billed cuckoo	Red-eyed vireo	Black capped chickadee
1970	9.54	12.10	4.98	10.01	3.56
1971	10.43	12.52	4.67	10.45	3.75
1972	9.77	12.90	4.80	9.79	3.64
1973	10.37	13.60	6.31	10.43	4.15
1974	9.97	12.58	4.56	11.05	4.35
1975	10.81	12.85	3.90	11.04	4.37
1976	10.68	11.96	4.33	11.83	4.09
1977	11.41	12.92	4.80	13.17	4.64
1978	9.86	12.58	6.16	13.90	4.00
1979	10.41	12.19	7.67	14.41	4.63
1980	10.06	12.30	5.24	13.68	5.71
1981	8.85	12.65	5.49	13.33	5.78
1982	8.99	12.00	5.00	13.06	4.99
1983	8.29	13.19	5.47	12.88	5.83
1984	8.00	13.00	4.86	12.73	5.65
1985	7.80	10.81	4.40	12.67	5.76

Source: U.S. Department of the Interior, Fish and Wildlife Service, Office of Migratory Bird Management. 1987. Migratory nongame birds of management concern: The 1987 list. Washington, D.C.

Table 5-5d.
Changes in bird populations of agricultural habitats (indexed number of birds per survey route), 1970-1985

Year	Horned lark	Eastern bluebird
1970	20.00	3.09
1971	18.16	3.21
1972	21.08	3.69
1973	21.97	2.88
1974	19.84	2.69
1975	21.38	2.99
1976	18.99	3.06
1977	21.10	2.24
1978	22.28	1.69
1979	22.73	2.08
1980	25.54	2.43
1981	25.85	2.86
1982	25.86	3.49
1983	23.48	3.82
1984	22.56	3.45
1985	22.82	3.99

Source: U.S. Department of the Interior, Fish and Wildlife Service, Office of Migratory Bird Management. 1987. Migratory nongame birds of management concern: The 1987 list. Washington, D.C.

Table 5-5e.
Changes in birds of prey populations (indexed number of birds per survey route), 1970-1985

Year	Red-tailed hawk	Logger-head shrike
1970	0.67	3.11
1971	0.59	3.14
1972	0.75	3.76
1973	0.72	2.69
1974	0.86	3.06
1975	0.78	2.86
1976	0.88	3.16
1977	0.88	2.69
1978	0.81	2.11
1979	0.82	2.25
1980	0.93	2.15
1981	0.95	2.13
1982	1.08	2.16
1983	1.10	1.88
1984	1.16	1.74
1985	1.04	1.62

Source: U.S. Department of the Interior, Fish and Wildlife Service, Office of Migratory Bird Management. 1987. Migratory nongame birds of management concern: The 1987 list. Washington, D.C.

Table 5-5f.
Changes in problem bird populations (indexed number of birds per survey route), 1970-1985

Year	European starling	Brown-headed cowbird
1970	60.32	14.07
1971	59.89	13.78
1972	57.31	14.10
1973	57.56	13.58
1974	60.02	13.60
1975	56.38	12.97
1976	58.90	13.65
1977	54.53	13.40
1978	46.64	12.93
1979	46.54	13.24
1980	49.48	13.77
1981	50.12	13.00
1982	49.90	13.00
1983	51.27	13.37
1984	51.00	12.84
1985	48.91	13.07

Source: U.S. Department of the Interior, Fish and Wildlife Service, Office of Migratory Bird Management. 1987. Migratory nongame birds of management concern: The 1987 list. Washington, D.C.

Table 5-7.
Changes in breeding populations of northern pintails and mallards (millions of birds) and canvasbacks and tundra swans (thousands of birds) in North America, 1955-1986

Year	Northern pintail	Mallard	Canvasback	Tundra swan
1955	9.251	10.345	595	NA
1956	10.124	11.711	692	NA
1957	6.856	10.946	600	NA
1958	6.889	12.904	713	NA
1959	7.228	10.292	481	NA
1960	5.769	8.206	575	NA
1961	4.860	8.290	396	NA
1962	4.299	6.144	385	NA
1963	4.361	7.360	523	NA
1964	4.111	6.974	658	NA
1965	4.301	5.948	505	NA
1966	5.777	7.401	683	NA
1967	5.870	8.205	556	NA
1968	4.225	7.586	557	NA
1969	6.390	8.065	530	NA
1970	7.004	10.379	601	55.0
1971	6.291	9.843	441	58.2
1972	7.875	9.867	429	62.8
1973	5.114	8.781	696	57.0
1974	7.165	7.392	493	64.0
1975	6.387	8.109	706	66.6
1976	6.045	8.637	686	78.6
1977	4.971	8.226	702	76.2
1978	5.664	7.695	423	70.2
1979	6.070	8.444	606	78.6
1980	5.420	8.003	688	63.5
1981	4.227	6.757	594	92.8
1982	4.112	6.684	543	72.9
1983	4.086	7.107	528	86.5
1984	3.664	5.974	569	81.1
1985	2.935	5.475	411	93.9
1986	3.201	6.351	442	NA

Source: U.S. Department of the Interior, Fish and Wildlife Service, Office of Migratory Bird Management in conjunction with the Canadian Wildlife Service. 1985. Status of waterfowl and fall flight forecast. Washington, D.C.

U.S. Department of the Interior, Fish and Wildlife Serice. 1987. (Draft) Environmental Impact Statement: Issuance of annual regulations permitting the sport hurting of migratory birds. Washington, D.C.

Table 5-8a.
Marine recreational fisheries catch for the Atlantic and Gulf coasts (millions), 1979-1987

Year	Number of fish caught	Number of fishing trips
1979	439	63
1980	463	74
1981	331	52
1982	371	61
1983	398	69
1984	356	62
1985	382	61
1986	411	61
1987	337p	66p

Source: U.S. Department of Commerce, National Oceanic and Atmospheric Administration. 1988. Fisheries of the United States, 1987: Current fishery statistics. no. 8700, p. 25. Washington, D.C.

Table 5-8b.
Marine recreational fisheries catch for the Pacific coast (millions), 1979-1987

Year	Number of fish caught	Number of fishing trips
1979	49	8
1980	84	15
1981	51	11
1982	53	11
1983	45	11
1984	47	10
1985	43	10
1986	55	11
1987	48p	10p

Source: U.S. Department of Commerce, National Oceanic and Atmospheric Administration. 1988. Fisheries of the United States, 1987: Current fishery statistics. no. 8700, p. 26. Washington, D.C.

Table 5-9.
Commercial landings of selected fish and shellfish by domestic fishermen in U.S. waters (millions of pounds), 1971-1987

Year	Atlantic herring	Clams	Haddock	Halibut	Alaskan pollock
1971	75.97	82.57	18.77	25.58	10.40c
1972	88.52	89.10	11.58	26.79	12.50c
1973	59.05	106.29	7.31	24.15	12.82c
1974	71.87	119.91	6.72	18.42	17.95c
1975	79.75	111.03	11.40	21.58	18.74c
1976	110.52	81.00	10.52	20.61	22.92c
1977	111.61	96.16	24.76	17.68	0.60c
1978	111.31	87.71	36.81	17.67	3.69c
1979	143.37	92.05	41.88	21.39	5.63c
1980	183.99	95.37	54.62	19.15	29.12c
1981	139.11	120.63	54.75	26.89	133.80c
1982	72.96	108.31	44.84	33.30	287.40c
1983	51.26	115.41	31.50	45.22	627.08c
1984	73.78	132.92	25.55	47.90	1003.42c
1985	57.13	150.55	14.35	60.97	1447.20c
1986	79.38	145.39	10.97	77.69	130.42
1987	84.54p	134.36p	6.67p	76.11p	522.05p

Source: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. 1986. Fisheries of the United States, 1985: Current fishery statistics, no. 8380. Washington, D.C.

Table 5-10a.
Extinction of animal groups (cumulative number of species and subspecies), 1780-1986

Year	Mammals	Birds	Fish
1780	2	0	0
1800	2	0	0
1820	2	0	0
1840	2	5	0
1860	2	7	0
1880	3	9	0
1900	7	20	0
1920	15	26	3
1940	24	33	7
1960	31	35	15
1980	34	37	25
1986	37	40	25

Source: U.S. Department of the Interior, Fish and Wildlife Service, Office of Endangered Species, unpublished data. 1986. Washington, D.C.

Table 5-10b.
Threatened and endangered U.S. wildlife and plants (cumulative number of species), 1980-1987

Wildlife	Threatened		Endangered	
	1980	1987	1980	1987
Mammals	3	7	32r	50
Birds	3	10	66r	76
Reptiles	10	18	13r	15
Amphibians	3r	4	5	5
Fishes	12	30	34r	47
Snails	5	5	2	3
Crustaceans	0	1	1	7
Insects	6r	7	7r	10
Arachnids	0	0	0	3
Clams	0	0	23	30
Plants	7	44	51	158
Total	49	126	234	404

Source: U.S. Department of the Interior, Fish and Wildlife Service, Division of Endangered Species and Habitat Conservation, unpublished data. 1987. Washington, D.C.

Table 5-10c.
Changes in selected threatened and endangered wildlife populations, 1941-1987

Year	Bald eagle (minimum estimate of nesting pairs)	Whooping crane (number in Texas-Canada flock)	Key deer (number of individuals)
1941	NA	16r	NA
1948	NA	30r	26r
1949	NA	34	30
1951	NA	25	NA
1964	600r	42	300
1968	NA	50r	NA
1969	NA	56	NA
1970	NA	57	NA
1971	NA	59	NA
1972	NA	51r	NA
1973	NA	49	400
1974	NA	49	NA
1975	850r	57	NA
1976	NA	69	NA
1977	NA	72	NA
1978	1000r	75	400
1979	1100r	76r	NA
1985	1900	97r	250
1987	2100p	148p	NA

Source: U.S. Department of the Interior, Fish and Wildlife Service, Division of Endangered Species and Habitat Conservation, unpublished data. 1987. Washington, D.C.

Table 6-2.
National Park System (number of units and millions of acres, cumulative), 1872-1987

Year	Units	Acreage
1872	1	2.2
1880	5	2.2
1890	12	3.8
1900	17	4.1
1910	45	7.9
1920	62	9.9
1930	92	10.8
1940	161	22.3
1950	182	24.6
1960	187	26.2
1970	282	29.6
1980	333	77.0
1986	337	79.5
1987	339	79.6

Source: U.S. Department of the Interior, National Park Service. Areas administered by the National Park Service, Information Tables, annual. Washington, D.C.

Table 6-3.
National Wildlife Refuge System (number of units, cumulative), 1920-1987

Year	Units
1920	36
1940	174
1960	245
1976	409
1985	430
1986	437
1987	442

Source: U.S. Department of the Interior, Fish and Wildlife Service, Office of Refuge Management, unpublished data. 1986. Washington, D.C.

Table 6-4a.
National Wilderness Preservation System (millions of designated acres, cumulative), 1964-1987

Year	Acreage	Year	Acreage	Year	Acreage
1964	9.24	1972	11.03	1980	79.71
1965	9.24	1973	11.03	1981	79.84
1966	9.24	1974	11.38	1982	79.88
1967	9.24	1975	12.72	1983	80.21
1968	10.03	1976	14.45	1984	88.55
1969	10.19	1977	14.49	1985	88.70
1970	10.40	1978	19.00	1986	88.80
1971	10.40	1979	19.00	1987	89.00

Source: U.S. Department of Agriculture, Forest Service. 1988. National Wilderness Preservation System, unpublished data. Washington, D.C.

Table 6-4b.

National Wilderness Preservation System by ownership category (millions of acres and percentage of total designated areas), 1985

Owner	Conterminous United States		Alaska	
	Acreage	Percentage	Acreage	Percentage
National Park Service	4.40	14	32.36	57
Bureau of Land Management	0.69	1	0.00	0
Forest Service	26.79	83	5.45	10
Fish and Wildlife Service	0.66	2	18.68	33

Source: U.S. Department of Agriculture, Forest Service. 1986. National Wilderness Preservation System, unpublished data. Washington, D.C.

Table 6-5.

National Wild and Scenic River System (river miles, cumulative), 1968-1987

Year	River miles
1968	773.25
1969	773.25
1970	868.25
1971	868.25
1972	895.25
1973	961.25
1974	1018.15
1975	1144.85
1976	1609.55
1977	1609.55
1978	2298.65
1979	2298.65
1980	5661.65
1981	6907.65
1982	6907.65
1983	6907.65
1984	7216.55
1985	7224.05
1986	7363.25
1987	7709.25

Source: U.S. Department of the Interior, National Park Service. 1988. River mileage classifications for components of the National Wild and Scenic River System, unpublished data. Washington, D.C.

Table 6-6.

National Estuarine Research Reserve System (thousands of acres, cumulative), 1974-1985

Year	Acreage
1974	4.50
1975	10.63
1976	16.53
1977	26.62
1978	26.62
1979	221.71
1980	337.71
1981	375.32
1982	389.85
1983	389.85
1984	392.51
1985	397.39

Source: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Marine and Estuarine Management Division, unpublished data. 1986. Washington, D.C.

Table 6-7.
National Register of Historic Places (properties listed and removed, cumulative), 1967-1987

Year	Listings	Removals
1967	873r	2
1968	903r	3
1969	1,106r	4
1970	1,888r	19
1971	3,026r	51
1972	4,376r	93
1973	6,646r	144
1974	8,247r	188
1975	10,805r	231
1976	12,561r	265
1977	14,203r	290
1978	16,575r	338
1979	20,589r	366
1980	24,680r	403
1981	26,499r	406
1982	29,999r	420
1983	35,112r	434
1984	39,121r	440
1985	42,538r	445
1986	45,936r	452
1987	48,403	NA

Source: U.S. Department of the Interior, National Park Service. 1988. The National Register of Historic Places, unpublished data. Washington, D.C.

Table 6-8.
Visitors to areas administered by the National Park Service (millions of visitors), 1905-1987

Year	Visitors	Year	Visitors	Year	Visitors
1905	0.141	1933	3.482	1931	68.901
1906	0.031	1934	6.337	1962	79.229
1907	0.061	1935	7.877	1963	86.663
1908	0.069	1936	11.990	1964	97.045
1909	0.086	1937	15.133	1965	102.711
1910	0.199	1938	16.332	1966	111.386
1911	0.224	1939	15.133	1967	121.312
1912	0.230	1940	16.332	1968	133.081
1913	0.252	1941	15.531	1969	139.676
1914	0.240	1942	16.755	1970	150.836
1915	0.335	1943	21.237	1971	163.990
1916	0.358	1944	9.371	1972	211.621
1917	0.491	1945	6.828	1973	215.580
1918	0.455	1946	8.340	1974	217.438
1919	0.812	1947	11.714	1975	238.849
1920	1.059	1948	21.752	1976	267.762
1921	1.172	1949	25.534	1977	262.603
1922	1.217	1950	29.859	1978	283.090
1923	1.494	1951	31.736	1979	282.435
1924	1.671	1952	33.253	1980	300.324
1925	2.055	1953	37.106	1981	329.663
1926	2.315	1954	47.379	1982	334.448
1927	2.798	1955	52.268	1983	335.644
1928	3.025	1956	54.210	1984	332.671
1929	3.248	1957	56.573	1985	346.190
1930	3.247	1958	61.602	1986	346.600
1931	3.545	1959	68.901	1987	372.900
1932	3.755	1960	65.461		

Source: U.S. Department of the Interior, National Park Service, Statistical Office. National Park statistical abstract, annual. Denver, CO.

Table 6-9.
Visibility impairment in National Parks

Current Status
Scenic vistas are affected by manmade pollution over 90 percent of the time. The worst visibility is in the East. The best visibility is in eastern Nevada, western Utah, and southern Idaho. The next best area is the Colorado Plateau. Visibility is worst in summer when meteorological conditions are such that more pollution is transported to remote areas from urban areas and industrial developments. Natural climatic conditions also contribute to reduced visibility during the summer. Fine particulates (<2.5 microns in diameter) are generally responsible for most of the visibility impairments. Fine sulfate particles from sulfur oxide emissions are the single most important contributor to visibility impairment, except in the northwestern United States where fine carbon particles play a more prominent role. Fine sulfates are responsible for 40 to 70 percent of visibility impairment. On the average, soil-derived materials are responsible for 10 to 30 percent of visibility impairment.

Source: U.S. Department of the Interior, National Park Service, Air and Water Quality Division. 1986. Highlights of findings of National Park Service Visibility Research, table 3-1, p. 3-3. Denver, CO.

Table 6-10.

Contaminant issues by level of concern on national wildlife refuges, 1987

Level of concern	Number of refuges	Examples of contaminant issues of concern on refuges
Evidence indicates the need for corrective action	9	Industrial wastes (DDT, PCBs) Agricultural drainwater (selenium, other trace elements) Military activities (nerve gas, mustard gas, dioxin, plutonium, DDT) Waste dumps (asbestos) Asbestos insulation (refuge buildings)
Evidence indicates the need for in-depth monitoring and analysis of impacts	26	Municipal/industrial/military wastes and discharges (PCBs, trace metals) Agricultural drainwater (ag-chemicals, selenium, arsenic, mercury, boron, other trace metals) Waste dumps (heavy metals, mercury, pesticides, cyanide, nutrients petroleum, other landfill effluents) Mining activities (mercury, arsenic, other trace elements) Cattle feedlots (nutrients)
Circumstantial evidence indicates a priority need for additional reconnaissance monitoring	43	Agricultural drainwater (ag-chemicals, trace elements, nutrients, toxic chemicals, metals, pesticides, selenium) Industrial dumps and discharges (petroleum byproducts, mercury, heavy metals, chemicals, trace elements) Industrial emissions Municipal wastes (trace elements, heavy metals, chemicals) Municipal and military landfills (polychlorinated compounds, trace elements) Buried drums (ag-chemical, PCBs, fuel, unknown contents) Mosquito control spraying (chemicals) Mining activities (cyanide, placer mining) Oil and gas activities

Source: U.S. Department of the Interior, Fish and Wildlife Service. 1986. (updated by agency). Preliminary survey of contaminants issues of concern on national wildlife refuges, pp. 10-14. Washington, D.C.

Table 7-2.
Total population (millions), including armed forces overseas, 1900-1987

Year	Population	Year	Population	Year	Population
1900	76.09	1930	123.19	1960	180.67
1901	77.58	1931	124.15	1961	183.69
1902	79.16	1932	124.95	1962	186.54
1903	80.63	1933	125.69	1963	189.24
1904	82.17	1934	126.49	1964	191.89
1905	83.82	1935	127.36	1965	194.30
1906	85.45	1936	128.18	1966	196.56
1907	87.01	1937	128.96	1967	198.71
1908	88.71	1938	129.97	1968	200.71
1909	90.49	1939	131.03	1969	202.68
1910	92.41	1940	132.59	1970	205.05
1911	93.86	1941	133.89	1971	207.66
1912	95.34	1942	135.36	1972	209.90
1913	97.23	1943	137.25	1973	211.91
1914	99.11	1944	138.92	1974	213.85
1915	100.55	1945	140.47	1975	215.97
1916	101.96	1946	141.94	1976	218.04
1917	103.41	1947	144.70	1977	220.24
1918	104.55	1948	147.21	1978	222.59
1919	105.06	1949	149.77	1979	225.06
1920	106.46	1950	152.27	1980	227.76
1921	108.54	1951	154.88	1981	230.14
1922	110.05	1952	157.55	1982	232.52
1923	111.95	1953	160.18	1983	234.80
1924	114.11	1954	163.03	1984	237.00
1925	115.83	1955	165.93	1985	239.28
1926	117.40	1956	168.90	1986	241.61r
1927	119.04	1957	171.98	1987	243.91
1928	120.51	1958	174.88		
1929	121.77	1959	177.83		

Source: U.S. Department of Commerce, Bureau of the Census. Current population reports, series P-25, nos. 521, 802, 990, and 1022. Washington, D.C.

Note: Annual population estimate as of July 1.

Table 7-3.
Population growth rate (percent change), 1901-1987

Year	Growth rate
1900	NA
1901	2.0
1902	2.0
1903	1.9
1904	1.9
1905	2.0
1906	1.9
1907	1.8
1908	2.0
1909	2.0
1910	2.1
1911	1.6
1912	1.6
1913	2.0
1914	1.9
1915	1.4
1916	1.4
1917	1.4
1918	1.1
1919	0.5
1920	1.3
1921	2.0
1922	1.4
1923	1.7
1924	1.9
1925	1.5
1926	1.4
1927	1.4
1928	1.2
1929	1.0
1930	0.9
1931	0.7
1932	0.6
1933	0.6
1934	0.7
1935	0.7
1936	0.6
1937	0.7
1938	0.8
1939	0.8
1940	0.9
1941	1.0
1942	1.3
1943	1.3
1944	1.2
1945	1.0
1946	1.5
1947	1.8
1948	1.7
1949	1.7
1950	1.7
1951	1.7
1952	1.7
1953	1.7
1954	1.8
1955	1.8
1956	1.8
1957	1.7
1958	1.7
1959	1.7
1960	1.6
1961	1.6
1962	1.5
1963	1.4
1964	1.3
1965	1.2
1966	1.1
1967	1.1
1968	1.0
1969	1.0
1970	1.3
1971	1.2
1972	1.0
1973	0.9
1974	0.9
1975	1.0
1976	1.0
1977	1.0
1978	1.1
1979	1.2
1980	1.1
1981	1.0
1982	1.0
1983	0.9
1984	0.9
1985	1.0
1986	0.9
1987	0.9

Source: U.S. Department of Commerce, Bureau of the Census. Current population reports, series P-25, nos. 521, 802, 990, and 1022. Washington, D.C.

Table 7-4.
Components of total population change (millions), 1940-1987

Year	Births	Deaths	Net civilian immigration	Net change
1940	2.570	1.432	0.077	1.221
1941	2.716	1.415	0.060	1.382
1942	3.002	1.407	0.083	1.714
1943	3.118	1.503	0.148	1.799
1944	2.954	1.582	0.202	1.597
1945	2.873	1.549	0.162	1.462
1946	3.426	1.409	0.151	2.165
1947	3.834	1.455	0.238	2.653
1948	3.655	1.453	0.280	2.533
1949	3.667	1.452	0.323	2.556
1950	3.645	1.468	0.299	2.486
1951	3.845	1.501	0.335	2.688
1952	3.933	1.512	0.242	2.663
1953	3.989	1.531	0.261	2.717
1954	4.102	1.489	0.287	2.898
1955	4.128	1.537	0.337	2.925
1956	4.244	1.572	0.387	3.058
1957	4.332	1.641	0.272	2.961
1958	4.279	1.655	0.292	2.915
1959	4.313	1.663	0.292	2.939
1960	4.307	1.708	0.328	2.901
1961	4.317	1.703	0.373	2.955
1962	4.213	1.758	0.351	2.771
1963	4.142	1.815	0.361	2.655
1964	4.070	1.799	0.317	2.555
1965	3.801	1.830	0.373	2.315
1966	3.642	1.869	0.455	2.197
1967	3.555	1.861	0.414	2.072
1968	3.535	1.948	0.398	1.952
1969	3.630	1.934	0.453	2.089
1970	3.739	1.927	0.438	2.617
1971	3.556	1.930	0.387	2.451
1972	3.258	1.965	0.325	2.068
1973	3.137	1.974	0.331	1.947
1974	3.160	1.935	0.316	1.999
1975	3.144	1.894	0.449	2.165
1976	3.168	1.910	0.353	2.084
1977	3.327	1.900	0.394	2.298
1978	3.333	1.928	0.508	2.388
1979	3.494	1.914	0.540	2.586

(continued)

Table 7-4 (continued)

Year	Births	Deaths	Net civilian immigration	Net change
1980	3.612	1.990	0.845	2.582
1981	3.629	1.979	0.718	2.371
1982	3.681	1.975	0.626	2.332
1983	3.639	2.020	0.605	2.224
1984	3.669	2.040	0.615	2.246
1985	3.761r	2.087r	0.650r	2.325r
1986	3.731r	2.100r	0.662r	2.293r
1987	3.809	2.124	0.599	2.285

Source: U.S. Department of Commerce, Bureau of the Census. Current population reports, series P-25, nos. 952, 990, and 1023. Washington, D.C.

Table 7-5.
Age structure of total population (millions), including armed forces overseas, 1940-1987

Year	Age class, in years							
	<5	5-14	15-24	25-34	35-44	45-54	55-64	>64
1940	10.6	22.3	24.0	21.5	18.4	15.6	10.7	9.0
1950	16.3	24.5	22.3	23.9	21.6	17.4	13.4	12.4
1960	20.3	35.7	24.6	22.9	24.2	20.6	15.6	16.7
1970	17.2	40.7	36.5	25.3	23.1	23.3	18.7	20.1
1980	16.5	34.8	42.7	37.6	25.9	22.8	21.8	25.7
1986	18.2r	33.9	39.0r	42.8r	33.1	22.8	22.2	29.2
1987	18.3	34.1	38.3	43.3	34.3	23.3	22.0	29.8

Source: U.S. Department of Commerce, Bureau of the Census. 1975. Historical statistics of the United States: Colonial times to 1970, series A 30-37. Washington, D.C.

U.S. Department of Commerce, Bureau of the Census. Current population reports, series P-25, nos. 311, 519, 917, and 1022. Washington, D.C.

Table 7-6a.
Net population migration by region (gains and losses, in millions), 1960-1985

Region	1960-1970	1970-1980	1980-1985
Northeast	0.375	-2.888	-0.327
Midwest	-0.752	-2.703	-1.771
South	0.592	5.992	3.436
West	2.854	4.115	2.193

Source: U.S. Department of Commerce, Bureau of the Census. 1979. Statistical abstract of the United States: 1978, no. 12, p. 15. Washington, D.C.

U.S. Department of Commerce, Bureau of the Census. 1986. Statistical abstract of the United States: 1985, no. 13, p. 13. Washington, D.C.

U.S. Department of Commerce, Bureau of the Census. 1986. State population and household estimates to 1985, with age and components of change, series P-26, no. 998. Washington, D.C.

Table 7-8a.
Population density in coastal and noncoastal areas of the United States (population per square mile), 1940-1985

Year	Noncoastal	Coastal	Total U.S.
1940	28.5	129.2	44.4
1950	30.9	157.2	50.8
1960	34.3	198.3	60.2
1970	37.6	232.0	68.2
1980	42.8	253.3	76.0
1985	44.6	263.9	79.1

Source: U.S. Department of Commerce, Bureau of the Census. 1982. Statistical abstract of the United States: 1981, no. 4, p. 7. Washington, D.C.

U.S. Department of Commerce, Bureau of the Census. 1987. Statistical abstract of the United States: 1986, no. 21, p. 19. Washington, D.C.

Note: Coastal area covers 611 counties and independent cities which are entirely or substantially within 50 miles of U.S. coastal shorelines.

Table 7-8b.
Population density by coastal region (population per square mile), 1940-1985

Year	Pacific	Gulf	Atlantic	Great Lakes
1940	64.1	44.8	244.4	140.9
1950	97.6	59.8	283.3	162.9
1960	142.7	83.1	341.6	197.3
1970	182.5	101	394.4	219.1
1980	215.8	134	414.9	222.4
1985	231.5	149	429.7	221.4

Source: U.S. Department of Commerce, Bureau of the Census. 1982. Statistical abstract of the United States: 1981, no. 4, p. 7. Washington, D.C.

U.S. Department of Commerce, Bureau of the Census. 1987. Statistical abstract of the United States: 1986, no. 21, p. 19. Washington, D.C.

Note: Coastal area covers 611 counties and independent cities which are entirely or substantially within 50 miles of U.S. coastal shorelines.

Table 7-8c.
Population density by coastal region (percent change), 1940-1985

Region	Percent change
Atlantic	77.9
Gulf	239.1
Pacific	270.7
Great Lakes	57.1
Noncoastal	60.0

Source: U.S. Department of Commerce, Bureau of the Census. 1982. Statistical abstract of the United States: 1981, no. 4, p. 7. Washington, D.C.

U.S. Department of Commerce, Bureau of the Census. 1987. Statistical abstract of the United States: 1986, no. 21, p. 19. Washington, D.C.

Note: Coastal area covers 611 counties and independent cities which are entirely or substantially within 50 miles of U.S. coastal shorelines.

Table 7-9.
Metropolitan and nonmetropolitan population patterns (percentage of population), 1950-1985

Year	Inside central cities of MSAs	Outside central cities of MSAs	Nonmetropolitan areas
1950	32.80	23.30	43.90
1960	32.30	30.60	37.10
1970	31.40	37.20	31.40
1980	30.00	44.80	25.20
1985	31.60	45.00	23.40

Source: U.S. Department of Commerce, Bureau of the Census. U.S. Census of Population: 1940, 1950, 1960, and 1970. CB86-118. Washington, D.C.

U.S. Department of Comerce, Bureau of the Census. Patterns of metropolitan area and county population growth: 1980-1984, 1986. Washington, D.C.

Note: MSAs=Metropolitan Statistical Areas.

Table 7-10a.
Trends in housing types in metropolitan and nonmetropolitan areas (millions of housing units), 1950-1980

Year	Metropolitan			Nonmetropolitan		
	Single family	Multi family	Mobile homes	Single family	Multi family	Mobile homes
1950	14.67	10.80	0.16	17.25	2.95	0.16
1960	24.22	11.77	0.38	19.53	2.03	0.38
1970	29.03	16.12	0.93	17.76	2.72	1.14
1980	40.34	22.05	2.24	16.85	3.11	2.17

Source: U.S. Department of Commerce, Bureau of the Census. U.S. census of housing: 1940, 1960, 1980. Washington, D.C.

Table 7-10b.
Trends in housing types by region (millions of housing units), 1940-1980

Year	Northeast			Midwest		
	Single family	Multi family	Mobile homes	Single family	Multi family	Mobile homes
1940	4.85	5.44	0.03	8.01	3.55	0.05
1950	6.25	5.77	0.03	9.67	3.97	0.11
1960	8.74	5.96	0.10	12.94	3.65	0.21
1970	8.78	7.18	0.24	13.43	4.75	0.50
1980	10.22	7.91	0.40	15.67	5.80	0.89

Year	South			West		
	Single family	Multi family	Mobile homes	Single family	Multi family	Mobile homes
1940	8.68	2.15	0.04	3.37	1.11	0.05
1950	11.05	2.52	0.08	4.94	1.49	0.10
1960	14.68	2.25	0.24	7.40	1.94	0.22
1970	16.24	3.78	0.87	8.35	3.13	0.47
1980	20.49	6.45	2.08	10.81	5.00	1.04

Source: U.S. Department of Commerce, Bureau of the Census. U.S. census of housing: 1940, 1960, 1980. Washington, D.C.

Table 8-1a.
Rural and municipal roads (millions of miles), 1925-1987

Year	Rural roads	Municipal roads
1925	3.01	0.24
1930	3.01	0.25
1935	3.03	0.28
1940	2.92	0.37
1945	2.94	0.38
1950	2.92	0.39
1955	2.95	0.46
1960	2.99	0.56
1965	3.01	0.68
1970	3.17	0.56
1975	3.20	0.64
1980	3.33	0.62
1985	3.17	0.69
1986	3.18	0.70
1987	3.16	0.71

Source: U.S. Department of Transportation, Federal Highway Administration. Highway statistics, table HM-10, annual issues. Washington, D.C.

Table 8-1b.
Railroads, airways, oil pipelines, inland waterways, and interstate highways (thousands of miles), 1940-1986

Year	Railroads	Airways	Oil pipelines	Inland waterways	Interstate highways
1940	224	37	124	24.7	NA
1945	227	50	138	24.8	NA
1950	224	81	158	25.0	NA
1955	221	171	188	25.1	NA
1960	218	293	190	25.3	10
1965	212	268	214	25.4	21
1970	206	291	219	25.5	32
1975	191	313	226	25.5	37
1980	165	341	218	25.5	41
1985	146	374	206	25.8	44r
1986	140	381	204	25.8	44

Source: Transportation Policy Associates. 1988. Transportation in America, p. 21. Washington, D.C.

American Association of Railroads. 1987. Railroad facts, p. 43.

U.S. Department of Transportation, Federal Highway Administration. Highway statistics, table HM-15, annual issues. Washington, D.C.

Table 8-2a.
Automobiles, trucks, motorcycles, and recreational boats (vehicles per 1,000 population), 1920-1987

Year	Automobiles	Trucks	Motorcycles	Recreational boats
1920	76.4	10.4	NA	NA
1925	150.9	22.2	NA	NA
1930	187.2	29.9	NA	NA
1935	177.4	30.8	NA	NA
1940	207.4	36.9	NA	NA
1945	193.3	38.0	NA	NA
1950	265.6	56.6	NA	NA
1955	315.9	62.3	NA	NA
1960	342.7	66.2	NA	NA
1965	388.9	76.4	7.1	32.7
1970	437.9	92.2	13.7	36.1
1975	500.9	121.0	23.0	54.6
1980	534.5	147.7	25.1	62.8
1984	541.2	157.8	23.1	66.3
1985	553.3	163.3	22.8	67.3
1986	561.7	166.6	21.8	68.3
1987	564.2	168.9	20.1	NA

Source: U.S. Department of Transportation, Federal Highway Administration. Highway statistics, table MV-1, updated, annual issues. Washington, D.C.

U.S. Department of Transportation, United States Coast Guard. 1985. Boating statistics, p. 11. Washington, D.C.

Note: Population data are from the U.S. Department of Commerce, Bureau of the Census. Statistical abstract of the United States, annual issues.

Table 8-2b.
Passenger and freight railroad cars (thousands), 1900-1986

Year	Passenger train cars	Freight cars	Year	Passenger train cars	Freight cars
1900	34.71	1365.53	1950	37.15	1721.27
1905	40.71	1731.41	1955	32.91	1698.81
1910	47.10	2135.12	1960	25.80	1660.00
1915	25.29	1103.09	1965	21.33	1478.01
1920	53.50	2322.12	1970	11.18	1784.18
1925	54.62	2357.23	1975	6.74	1723.61
1930	52.10	2275.00	1980	4.35	1710.83
1935	41.58	1835.74	1985	2.50	1421.69
1940	38.31	1706.39	1986	2.31	1339.45
1945	38.27	1760.30			

Source: Association of American Railroads. 1987. Railroad facts, pp. 46, 50. Washington, D.C.

Table 8-2c.
Buses and aircraft (per 1,000 population), 1930-1987

Year	Buses	Aircraft
1930	0.33	0.08
1935	0.46	0.07
1940	0.76	0.14
1945	1.20	0.28
1950	1.50	0.61
1955	1.50	0.52
1960	1.50	0.65
1965	1.60	0.73
1970	1.90	0.76
1975	2.20	0.92
1980	2.30	1.13
1984	2.50	1.15r
1985	2.49	1.15
1986	2.46	1.14
1987	2.47	NA

Source: U.S. Department of Transportation, Federal Highway Administration. Highway statistics, table MV-1, annual issues. Washington, D.C.

U.S. Department of Commerce, Bureau of the Census. 1985. Statistical abstract of the United States: 1988, no. 1084. p. 595. Washington, D.C.

Table 8-3.
Intercity passenger travel (miles per capita), 1940-1987

Year	Automobile	Aircraft	Bus	Railroad
1940	2209.8	9.9	77.0	187.2
1945	1651.0	32.2	205.3	700.7
1950	2886.1	66.5	149.5	214.0
1955	3861.4	138.1	132.7	173.9
1960	3923.2	188.9	110.6	120.0
1965	4224.8	300.2	123.0	90.9
1970	5034.1	581.9	124.1	53.5
1975	5271.5	686.0	119.2	47.4
1980	5710.1	962.0	120.3	48.3
1985	5927.3	1211.0r	106.8	47.6
1986	6002.2	1325.8	98.1	50.1
1987	6127.4p	1400.9p	95.6p	49.6p

Source: Transportation Policy Associates. 1988. Transportation in America, p. 8. Washington, D.C.

Note: Population data are from the U.S. Department of Commerce, Bureau of the Census. Statistical abstract of the United States, annual issues.

Table 8-4.
Intercity freight transportation (ton-miles per capita), 1940-1987

Year	Truck	Railroad	Air	Oil pipeline	Inland waterway
1940	468.1	2861.3	0.2	454.4	870.9
1945	502.1	5178.6	0.7	951.8	1071.7
1950	1139.1	3931.0	2.0	849.4	1079.9
1955	1350.9	3822.6	3.0	1229.8	1314.6
1960	1583.5	3217.1	4.9	1272.4	1222.4
1965	1855.0	3663.6	9.9	1531.2	1353.8
1970	2021.5	3782.9	16.2	2114.7	1565.2
1975	2131.1	3562.8	17.5	2379.9	1605.4
1980	2437.0	4092.4	21.2	2581.9	1787.1
1985	2549.3	3740.3	25.4	2357.0	1596.4r
1986	2624.2	3879.7	30.4	2392.4	1626.7
1987	2732.1p	4003.7p	35.7p	2407.0p	1784.5p

Source: Transportation Policy Associates. 1988. Transportation in America. p. 6. Washington, D.C.

Note: Population data are from the U.S. Department of Commerce, Bureau of the Census. Statistical Abstract of the United States, annual issues.

Table 8-5.
Means of transportation to work (percent of workers), 1960-1980

Year	Drive alone	Car-pool	Public transit	Walk or other
1960	67	0	13	20
1970	66	12	8	14
1980	64	20	6	10

Source: U.S. Department of Commerce, Bureau of the Census. 1977. Residential energy uses. Current housing reports, series H-123, special reports, chart 6. Washington, D.C.

U.S. Department of Commerce, Bureau of the Census. 1979. Annual housing survey: 1977, part A, p. 6, and previous issues. Washington, D.C.

U.S. Department of Transportation, Federal Highway Administration, unpublished data. 1986. Washington, D.C.

Table 8-6.
Automobile fuel economy (miles per gallon), 1975-1987

Year	Estimate for new cars	Estimate for all cars
1975	15.8	13.9
1976	17.5	14.9
1977	18.3	15.7
1978	19.9	18.0r
1979	20.3	19.0r
1980	23.5	20.0r
1981	25.1	22.0r
1982	26.0	24.0r
1983	25.9	26.0r
1984	26.3	27.0r
1985	27.0	27.5r
1986	28.0	26.0r
1987	NA	26.0

Source: U.S. Department of Energy, Oak Ridge National Laboratory. 1988. Transportation energy conservation data book (draft dated May 31, 1988, data may be subject to change). Oak Ridge, Tenn.

Table 9-2a
Municipal solid waste generation and recovery (millions of tons), 1960-1984

Year	Gross waste generated	Resources recovered
1960	82.3	5.9
1965	98.3	6.2
1970	118.3	8.0
1975	122.7	9.1
1980	139.1	13.4
1984	148.1	15.1

Source: Franklin Associates, Ltd., Prairie Village, KS. 1986. Characterization of municipal solid waste in the United States, 1960 to 2000. Prepared for the U.S. Environmental Protection Agency. Washington, D.C.

Table 9-2b.
Municipal solid waste generation and recovery (pounds per capita per day), 1960-1984

Year	Gross waste generated	Resources recovered
1960	2.50	0.18
1965	2.77	0.17
1970	3.16	0.21
1975	3.11	0.23
1980	3.35	0.32
1984	3.43	0.35

Source: Franklin Associates, Ltd., Prairie Village, KS. 1986. Characterization of municipal solid waste in the United States, 1960 to 2000. Prepared for the U.S. Environmental Protection Agency. Washington, D.C.

Table 9-2c.
Municipal solid waste recovered by waste type (percentage of gross discards), 1960-1984

Year	Paper	Glass	Metal	Aluminum	Rubber
1960	18.8	1.4	0.5	NA	5.7
1965	15.8	1.2	1.0	NA	12.5
1970	16.0	1.3	1.2	1.3	8.2
1975	15.5	2.7	4.4	8.7	6.9
1980	20.6	4.9	4.1	14.8	3.9

Source: Franklin Associates, Ltd., Prairie Village, KS. 1986. Characterization of municipal solid waste in the United States, 1960 to 2000. Prepared for the U.S. Environmental Protection Agency. Washington, D.C.

Table 9-2d.
Municipal solid waste discarded by waste type (percentage of net discards), 1960-1984

Year	Paper	Glass	Metals	Plastics	Food	Yard	Miscellaneous
1960	32.1	8.4	13.7	0.5	14.6	20.3	10.4
1965	35.0	9.2	11.6	1.5	13.1	19.2	10.3
1970	33.1	11.3	12.2	2.7	11.5	19.0	11.2
1975	30.4	11.6	11.8	3.9	11.8	19.5	11.2
1980	33.6	11.3	10.3	6.0	9.2	18.2	11.3
1984	37.1	9.7	9.6	7.2	8.1	17.9	10.3

Source: Franklin Associates, Ltd., Prairie Village, KS. 1986. Characterization of municipal solid waste in the United States, 1960 to 2000. Prepared for the U.S. Environmental Protection Agency. Washington, D.C.

Note: Miscellaneous waste includes rubber, leather, textiles, wood, and other wastes. Net discards are those remaining after materials recovery and before energy recovery.

Table 9-2e.
Municipal solid waste processed for energy recovery (millions of tons), 1965-1984

Year	Amount
1965	0.2
1970	0.4
1975	0.7
1980	2.7
1984	6.5

Source: Franklin Associates, Ltd., Prairie Village, KS. 1986. Characterization of municipal solid waste in the United States, 1960 to 2000. Prepared for the U.S. Environmental Protection Agency. Washington, D.C.

Table 9-3a.
Industrial solid waste disposal (million short tons), 1975-1983

Year	Total
1975	139.1
1976	156.8
1977	160.0
1978	160.8
1979	163.7
1980	149.8
1981	145.8
1982	99.4
1983	89.0

Source: U.S. Department of Commerce, Bureau of the Census. Current industrial reports, series MA-200, annual. Washington, D.C.

Table 9-3b.
Solid waste disposal by industrial sector (million short tons), 1974-1983

Year	Food processing	Primary Metals	Fabricated metals	Chemicals	Petroleum	Wood products	Paper	Stone, clay & glass	Machinery (excluding electrical)	Electrical equipment	Transportation equipment
1975	12.6	42.7	1.9	38.7	2.0	8.1	9.1	11.3	2.7	1.5	3.8
1976	15.0	42.2	2.1	50.3	2.6	9.3	10.1	11.1	3.1	1.5	4.3
1977	13.1	41.7	2.0	55.7	2.9	6.3	10.6	12.6	3.6	1.5	4.7
1978	13.4	46.1	2.0	48.8	3.6	6.7	10.9	12.7	3.4	1.8	5.2
1979	14.0	47.8	2.0	45.4	3.1	6.5	13.3	14.1	3.5	2.3	4.3
1980	14.4	37.5	1.9	43.4	4.9	5.9	12.3	13.3	3.0	2.1	4.2
1981	13.2	36.0	1.8	43.7	4.7	6.4	11.3	12.1	2.8	1.7	4.0
1982	9.8	16.7	1.4	36.1	4.4	3.7	11.5	5.8	1.6	1.3	2.9
1983	9.6	17.7	2.0	18.8	3.6	4.0	13.7	6.2	1.8	1.7	3.0

Source: U.S. Department of Commerce, Bureau of the Census. Current industrial reports, series MA-200, annual. Washington, D.C.

Table 9-3c.
Hazardous waste disposal by industrial sector (percentage of net discards), 1983

Industrial sector	Hazardous discards
Food	2.1
Lumber & wood	1.3
Paper	0.7
Chemical	19.2
Petroleum	41.7
Stone, clay, glass	3.3
Primary metal	5.7
Fabricated metals	10.0
Machinery, excluding electronic	12.2
Electronic equipment	17.7
Transportation equipment	10.0

Source: U.S. Department of Commerce, Bureau of the Census. Current industrial reports, series MA-200, annual. Washington, D.C.

Table 9-5.
Domestic production of selected industrial chemicals (million pounds), 1950-1987

Year	Acrylo-nitrile	Benzene (all grades)	Vinyl (monomer) chlorides	Phthalates (anhydride phthalic)	PCBs
1950	NA	NA	0.250	0.143	NA
1955	0.1179	NA	0.529	0.213	NA
1960	0.2292	NA	1.037	0.345	0.0379
1961	0.2495	NA	1.044	0.377	0.0365
1962	0.3601	NA	1.312	0.470	0.0384
1963	0.4553	NA	1.435	0.522	0.0447
1964	0.5942	NA	1.615	0.601	0.0508
1965	0.7716	6.0764r	2.000	0.679r	0.0605
1966	0.7161	7.0202r	2.500	0.755r	0.0658
1967	0.6708	7.1236r	2.424	0.784r	0.0753
1968	1.0210	7.4998r	2.969	0.841r	0.0829
1969	1.1566	9.0068r	3.736	0.884r	0.0764
1970	1.0393	8.6944r	4.040	0.855r	0.0851
1971	0.9789	7.9068r	4.336	0.978r	0.0405
1972	1.1147	9.2048r	5.089	1.146r	0.0386
1973	1.3542	10.6778r	5.351	1.203r	0.0422
1974	1.4117	10.9362r	5.621	1.207r	0.0411
1975	1.2146	7.5218r	4.196	0.904r	0.0297
1976	1.5178	10.4720r	5.677	1.043r	0.0296
1977	1.6460	10.5490r	5.986	1.202r	0.0133
1978	1.7523	10.9362r	6.941	1.259r	0.0000
1979	2.0178	12.2892r	7.544r	1.291r	0.0000
1980	1.8299	11.6424r	6.466	1.054r	0.0000
1981	1.9964	9.8384r	6.874	1.120r	0.0000
1982	2.0352	7.8518r	6.495r	0.952r	0.0000
1983	2.1462	9.6954r	6.875	1.147r	0.0000
1984	2.2192	10.0034r	6.085	1.179r	0.0000
1985	2.3488	10.2542	9.463	0.820	0.0000
1986	2.3144	NA	8.439	0.860	0.0000
1987	2.5000e	NA	NA	1.015e	0.0000

Source: U.S. International Trade Commission. Synthetic organic chemicals, 1985; 1986. Washington, D.C.

Note: There has been no production of PCBs since 1978 as per U.S. Environmental Protection Agency. 1976. Toxic Substances Control Act. (Pub.L. 94-469), section 6. Regulation of hazardous chemicals and mixtures, (e) Polychlorinated biphenyls. Washington, D.C.

Table 9-6a.
Toxic residues in human adipose tissue (geometric means, lipid adjusted, in parts per million and percentage of population with PCB detected), 1970-1983

Year	DDT (ppm)	PCB		Dieldrin (ppm)	Oxychlordane (ppm)
		1-3 ppm(%)	>3 ppm(%)		
1970	7.95	NA	NA	0.16	NA
1971	8.06	NA	NA	0.22	NA
1972	6.97	62.40	6.00	0.18	0.10
1973	5.96	31.70	5.80	0.17	0.12
1974	5.15	34.70	5.20	0.14	0.12
1975	4.76	27.60	10.70	0.12	0.11
1976	4.35	29.60	9.20	0.09	0.11
1977	3.14	21.20	11.90	0.09	0.10
1978	3.52	21.60	12.10	0.09	0.11
1979	3.10	18.20	4.00	0.08	0.10
1980	2.82	28.60	4.10	0.10	0.12
1981	2.24	15.60	0.50	0.05	0.09
1982	NA	NA	NA	NA	NA
1983	1.67	8.60	0.00	0.06	0.09

Source: U.S. Environmental Protection Agency, Office of Pesticides and Toxic Substances. 1986. Unpublished data from the National Human Adipose Tissue Survey of the National Human Monitoring Program. Washington, D.C.

Table 9-6b.
Toxic residues in human adipose tissue (geometric means, lipid adjusted, in parts per million and percentage of population with PCB detected), 1970-1983

Year	Heptachlor epozide (ppm)	Beta-benzene hexachloride (ppm)	Hexachlorobenzene (ppm)
1970	0.09	0.37	NA
1971	0.09	0.35	NA
1972	0.07	0.19	NA
1973	0.09	0.25	NA
1974	0.08	0.21	0.03
1975	0.08	0.19	0.04
1976	0.08	0.18	0.04
1977	0.07	0.14	0.04
1978	0.07	0.14	0.04
1979	0.07	0.15	0.04
1980	0.08	0.12	0.04
1981	0.09	0.09	0.04
1982	NA	NA	NA
1983	0.09	0.10	0.03

Source: U.S. Environmental Protection Agency, Office of Pesticides and Toxic Substances. 1986. Unpublished data from the National Human Adipose Tissue Survey of the National Human Monitoring Program. Washington, D.C.

Table 9-7a.
Radiation exposure of United States population by source (percentage of total exposure), 1986

Source	Percentage
Natural background	67.60
Medical	30.70
Global nuclear fallout	0.60
Occupational	0.45
Nuclear fuel cycle	0.15
Miscellaneous	0.50

Source: U.S. Department of Energy. 1986. Understanding radiation. DOE/NE-0074. Oak Ridge, TN.

Note: On the average, people in the United States receive 180 millirems of radiation per year.

Table 9-7b.
Radiation levels from nuclear fallout as measured by strontium-90 in pasteurized milk (annual mean exposure in picocuries per liter), 1960-1986

Year	Exposure
1960	8.6
1961	8.0
1962	13.4
1963	23.5
1964	23.8
1965	17.6
1966	13.3
1967	10.2
1968	8.9
1969	7.5
1970	7.3
1971	6.8
1972	5.6
1973	4.4
1974	4.7
1975	3.9
1976	3.5
1977	3.6
1978	3.8
1979	3.5
1980	2.8
1981	2.8
1982	2.8
1983	2.3
1984	2.1
1985	2.0
1986	1.9

Source: U.S. Environmental Protection Agency, Office of Radiation Programs, unpublished data.1986. Montgomery, AL.

Table 9-7c.
Radiation levels from nuclear fallout as measured by cesium-137 in pasteurized milk (seasonal mean exposure in picocuries per liter), 1960-1986

Year	Exposure
1960	18.0
1961	11.0
1962	44.0
1963	108.0
1964	109.0
1965	58.0
1966	29.0
1967	16.0
1968	11.0
1969	9.0
1970	8.0
1971	9.0
1972	6.0
1973	5.0
1974	8.0
1975	9.0
1976	7.0
1977	6.0
1978	7.3
1979	4.0
1980	6.8
1981	2.5
1982	4.1
1983	1.6
1984	2.1
1985	2.7
1986	4.4

Source: U.S. Environmental Protection Agency, Office of Radiation Programs. 1986. Unpublished data. Montgomery, AL.

Note: Data for 1986 are for the first 6 months of the calendar year only.

Table 9-7d.
Radiation levels from nuclear power generation, as measured by krypton-85 in air (annual mean exposure in picocuries), 1962-1983

Year	Exposure
1962	7.50
1963	9.00
1964	9.50
1965	10.00
1966	11.00
1967	11.50
1968	12.50
1969	13.50
1970	15.40
1971	14.80
1972	14.90
1973	16.70
1974	17.01
1975	17.48
1976	16.51
1977	17.10
1978	NA
1979	21.80
1980	NA
1981	NA
1982	26.40
1983	38.55

Source: U.S. Environmental Protection Agency, Office of Radiation Programs, unpublished data. 1986. Montgomery, AL.

Table 9-8a.
Radioactivity accumulation from nuclear reactor spent fuel (billions of curies), 1970-1987

Year	Accumulation	Year	Accumulation	Year	Accumulation
1970	0.214r	1976	4.559r	1982	10.522r
1971	0.410r	1977	5.771r	1983	12.151r
1972	1.200r	1978	7.807r	1984	13.198r
1973	1.027r	1979	8.940r	1985	14.166
1974	2.390r	1980	10.175r	1986	15.615
1975	3.212r	1981	10.661r	1987	17.646

Source: U.S. Department of Energy. 1988. Integrated data base for 1988: Spent fuel and radioactive waste inventories, projections, and characteristics, p. 31. Washington, D.C.

Table 9-8b.
Radioactivity of low-level radioactive waste (millions of curies) and high-level radioactive waste (billions of curies), 1980-1987

Year	Low-level DOE/defense waste	Low-level commercial waste	High-level waste*
1980	9.250r	4.557r	1.345r
1981	9.586r	4.497r	1.611r
1982	10.637r	4.586r	1.349r
1983	11.222r	4.752r	1.281r
1984	12.284r	4.976r	1.428r
1985	12.165	5.308	1.496
1986	12.015	5.089	1.444
1987	13.992	4.960	1.304

Source: U.S. Department of Energy. 1988. Integrated data base for 1988: Spent fuel and radioactive waste inventories, projections, and characteristics, pp. 49, 60, 114, 115. Washington, D.C.

Note: DOE = U.S. Department of Energy. *= Includes both DOE/defense and a small amount of commercial high-level waste at the West Valley Demonstration Project.

Table 9-8c.
Historical volume of uranium mill tailings (million cubic meters), prior to 1978 to 1987

Year	Accumulation
Prior to 1978	68.0
1978	75.8
1979	84.9
1980	94.4
1981	102.7
1982	107.7
1983	111.1
1984	113.6
1985	114.6
1986	115.4
1987	116.2

Source: U.S. Department of Energy. 1988. Integrated data base for 1988: Spent fuel and radioactive waste inventories, projections, and characteristics, pp. 49, 60, 114, 115. Washington, D.C.

Table 9-9b.
Number of tornadoes and lives lost in tornadoes (number), 1916-1986

Year	Tornadoes	Lives lost
1916	90	150
1917	121	551
1918	81	136
1919	64	206
1920	87	499
1921	105	202
1922	108	135
1923	102	110
1924	130	376
1925	119	794
1926	111	144
1927	163	540
1928	203	95
1929	197	274
1930	192	179
1931	94	36
1932	151	394
1933	258	362
1934	147	47
1935	180	71
1936	151	552
1937	147	29
1938	213	183
1939	152	91
1940	124	65
1941	118	53
9142	167	384
1943	152	58
1944	169	275
1945	121	210
1946	106	78
1947	165	313
1948	183	139
1949	249	211
1950	200	70
1951	262	34
1952	240	229
1953	421	515
1954	550	36
1955	593	126
1956	504	83
1957	856	192
1958	564	66
1959	604	58
1960	616	46
1961	697	51
1962	657	28
1963	464	31
1964	704	73
1965	906	299
1966	585	98
1967	926	114
1968	660	131
1969	608	66
1970	653	72
1971	888	156
1972	741	27
1973	1102	87
1974	947	361
1975	920	60
1976	835	44
1977	852	43
1978	788	53
1979	852	84
1980	866	28
1981	783	24
1982	1046	64
1983	931	34
1984	907	122
1985	684	94
1986	764	15

Source: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Climatic Data Center. 1987. Storm data 1987. Asheville, N.C.

Table 9-9c.
Average number of tornadoes and tornado day per month, 1953-1986

Month	Average number of tornadoes	Average number of tornado days
January	13	4
February	20	6
March	50	12
April	109	18
May	166	25
June	150	26
July	82	25
August	57	21
September	38	14
October	24	8
November	22	6
December	19	5

Source: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Climatic Data Center. 1987. Storm data 1987. Asheville, N.C.

Table 9-11b.
North Atlantic hurricanes (number of hurricanes with winds 65 mph or greater), 1931-1986

Year	Number
1931	2
1932	6
1933	9
1934	6
1935	5
1936	7
1937	3
1938	3
1939	3
1940	4
1941	4
1942	4
1943	5
1944	7
1945	5
1946	3
1947	5
1948	6
1949	7
1950	11
1951	8
1952	6
1953	6
1954	8
1955	9
1956	4
1957	3
1958	7
1959	7
1960	4
1961	8
1962	3
1963	7
1964	6
1965	4
1966	7
1967	6
1968	5
1969	12
1970	5
1971	6
1972	3
1973	4
1974	4
1975	6
1976	6
1977	5
1978	5
1979	5
1980	9
1981	7
1982	2
1983	3
1984	5
1985	7
1986	4
TOTAL	311

Source: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Climatic Data Center. 1987. Storm data 1987. Asheville, N.C.

Table 9-11c.
Lives lost in hurricanes (number) and property damages suffered (millions of dollars), 1900-1987

Period	Lives lost	Damages
1900-04	>6000	NA
1905-09	2100	NA
1910-14	50	NA
1915-19	1000	1717.5
1920-24	30	68.8
1925-29	2100	1236.8
1930-34	20	584.0
1935-39	1030	2885.8
1940-44	160	1752.1
1945-49	60	1683.4
1950-54	200	3332.4
1955-59	570	4603.5
1960-64	185	3985.1
1965-69	385	8348.3
1970-74	146	8909.5
1975-79	80	4165.6
1980-84	31c	12,600.0r
1985-87	39p	3758.0p

Source: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Climatic Data Center. 1984. The federal plan for meteorological services and supporting research. FCM-P1-1983. Asheville, NC.

U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Climatic Data Center. Storm data, 1980; 1981; 1982; 1983; 1984; 1985; 1986; 1987, vols. 22-29, no. 12, table 1. Asheville, NC.

Note: 1980 dollars

Table 9-12.
Lives lost in floods (number) and damages suffered and prevented (billions of dollars), 1973-1987

Year	Lives lost	Damages suffered	Damages prevented
1973	150	1.9	11.9
1974	125	0.6	13.0
1975	110	1.2	15.9
1976	187	2.1	1.7
1977	213	1.3	2.6
1978	125	1.0	6.3
1979	103	3.5	19.4
1980	99	1.5	7.3
1981	90	1.0	1.2
1982	155	1.5	4.3
1983	200	4.0	23.2
1984	125	3.5	16.8
1985	63	0.5	10.8
1986	208	6.0	27.3
1987	88	1.5	5.2

Source: U.S. Department of Defense, Army Corps of Engineers Headquarters, Flood damages data compiled by D. Wingerd, HQ USACE(CEEC-EH-W). Washington, D.C.

Note: Damages prevented by dams controlled by the U.S. Army Corps of Engineers.